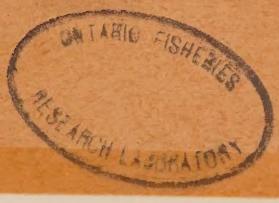
Canada. Dept. of Agriculture.
Forest Insect Investigations Unit.
Forest Entomology in the Province of Ontario. A Brief presented to the Ontario Royal Commission on Forestry.

CANADA.

DEPT. AGR. FOREST INSECT INVESTIGATIONS UNIT.

Forest Entomology in the Province of Ontario.
A brief presented before the Ontario Royal Commission on Forestry.

(Dec., 1946).



FOREST ENTOMOLOGY
IN
THE PROVINCE OF ONTARIO

A Brief

Presented before the Ontario Royal Commission

on Forestry

by

The Forest Insect Investigations Unit

Division of Entomology

Science Service

Department of Agriculture

OTTAWA

Ottawa, Canada December, 1946

Foreword

"In the natural order of things, insects are part and parcel of that great economy commonly referred to as the "balance of nature". The forest is a vast biological unit composed of plants and animals; it is perpetually subject to changes through the succession of species and individual organisms competing with each other for a place in the sun, and its composition at any one point of time is the resultant of the complicated interaction of all its vegetational and animal components, itself again dominated by climatic and edaphic conditions. In this intricate scheme of relationships insects play a dual regulatory role. Some, namely the herbivorous species, act upon the vegetation while others, endowed with carnivorous instincts, control the excessive multiplication of the first. Vegetarian insects may be roughly divided into two great classes; those which feed upon healthy living trees and are therefore designated as primary; and those which attack only sickly, dead, or dying trees and, as such, are usually designated as secondary. Considered from the standpoint of man's economy, the primary insects are, potentially at least, the most injurious, and the majority of so-called destructive species are found among them. From the standpoint of nature's economy, they really act as useful protectors of those tree species whose existence becomes threatened by the undue dominance of others. Generally speaking, secondary insects, by hastening the death of weakened trees or by contributing to the decomposition of dead trees, are useful agents in the regeneration of forests, by the removal of trees which have reached the natural limit of their existence.

When, therefore, we refer to insects as pests or destructive enemies of the forest we speak in terms of human relationships and we forget that, more than often, man himself is the prime mover in the calamities which are visited upon him. Our knowledge of insect ecology is still very imperfect and it would be absurd to pretend that all the causal relationships underlying the rise and fall of any one insect outbreak can be determined. However, the fixing of man's responsibility is, in many cases, a comparatively simple matter. Improvident and reckless exploitation, ill-planned reforestation, destruction of wild life, fire, and the importation of insect species from foreign lands are broad categories under which man's offences may be readily classified. In planning measures of prevention and control, our first concern must be the regulation of man's activities and the correction of his mistakes. In some cases, appropriate legislation is the only course, in others the education of the individual will be more effective.

In any event, whether legislative or educational procedure is to be adopted, it should be based at all times upon as thorough a knowledge of natural processes as it is possible to obtain." *

In this brief, we are chiefly concerned with some of the "primary" destructive forest insects of Ontario. The history of their outbreaks contained here is admittedly incomplete, due partly to serious deficiencies in surveys and research in this important field until very recently, and partly to past tendencies to deprecate the importance of devastations affecting timber species not currently being exploited commercially, or occurring in areas not currently accessible. Even though incomplete, this record of insect devastation in Ontario, and of investigations and activities now in progress, will, it is hoped, provide the basis for a better understanding of the complex problems involved, and of the course of action most likely to bring such losses to a minimum in the future.

Many members of the Forest Insect Investigations Unit of the Dominion Department of Agriculture have contributed in the preparation of this brief. M. L. Prebble, officer-in-charge of the Forest Insect Laboratory, Sault Ste. Marie, was assigned chief responsibility in this project. All members of the Sault Ste. Marie Laboratory staff, Mr. D. E. Gray of headquarters staff, Ottawa, and Messrs. E. B. Watson and K. E. Stewart of the Ottawa Laboratory staff, have contributed material or provided assistance. Valuable information has been obtained from reports prepared by Dr. J. M. Swaine, J. J. de Gryse, C. E. Atwood, H. A. Richmond, R. R. Lejeune, and others, and from the Annual Reports of the Forest Insect Survey, 1936 - 1945.

* From "Noxious forest insects and their control", by J. J. de Gryse, Chief, Forest Insect Investigations, Department of Agriculture, Ottawa, in the Canada Year Book, 1945, Department of Trade and Commerce.

CONTENTS

INTRODUCTION

The commercial forests of Ontario are composed principally of some eight or nine tree species of which spruce constitutes approximately 60 per cent of the total timber resources of the Province and which is used annually to the extent of approximately 65 per cent of the total annual production. Jack pine constitutes approximately 25 per cent of the Provincial forest resources and approximately 8 per cent of production in recent years; and will undoubtedly become more important with the passage of time. White and red pine together made up approximately 7 per cent of the estimated resources in 1930; and in recent years approximately 15 per cent of the total annual production. It is evident that less dependence can be placed on available resources of these valuable timber species as time goes on, unless young stands are successfully established for future use. Balsam fir was estimated at approximately 8 per cent of the total resources in 1930 and is being used currently to the extent of about 5 per cent of the total annual production. Recent widespread destruction of balsam fir will undoubtedly even further reduce the relative importance of this timber species in the future, at least until young stands now established reach merchantable size. Maple and yellow birch, together, constituted less than one half of one per cent of the estimated resources in 1930 and are being utilized currently to the extent of approximately 3 per cent of the total annual production. Various species which were not included in the 1930 estimate of the forest resources are being utilized to the following degree: hemlock - 3 per cent, aspen - 2 per cent, other hardwoods, cedar and larch, to the extent of about one-half per cent. *

Among the timber species making up the principal components of the annual production in Ontario, several are seriously affected by forest insects. Although balsam fir has a relatively minor role in present forest operations, the species has assumed disproportionate importance in the forest economy through a chain of circumstances as follows: firstly, the species tends to occur in mixture with spruce, other conifers and also hardwoods; secondly, the species is disastrously affected by outbreaks of the spruce budworm as well as being implicated in their origin; thirdly, the consequences of such outbreaks extend far beyond the destruction of the balsam fir because white spruce also is frequently killed; fourthly, the resulting destruction of timber frequently makes impossible the economic utilization of the residual unkilled volumes, the fire hazard is immeasurably increased for years to come, and regeneration in such

* Data relative to the forest resources of Ontario have been taken from the following Department of Lands and Forests publications: "The Forest Resources of Ontario" by J.F. Sharpe and J.A. Brodie, 1930; and the "Annual Reports of the Minister of Lands and Forests" for the fiscal years ending March 31st, 1942, 1943 and 1944.

devastated lands tends to run high to balsam fir, thereby setting the stage for a recurrence of the disaster at some future date, probably on an enlarged scale.

Jack pine is especially susceptible to deterioration consequent upon insect attack, particularly the jack pine budworm and several native species of sawflies. This susceptibility to deterioration following insect attack is enhanced in some territories by the marginal sites occupied by jack pine stands where growing conditions are so precarious that any undue disturbance is liable to have serious consequences. At present numerous jack pine stands in northern Ontario are undergoing progressive deterioration, the cause of which cannot be stated explicitly although past and present insect activity is involved in the process.

Mature stands of white and red pine have not in the past suffered undue damage from insect outbreaks in Ontario, but the role of insects in the production of viable seed and in the establishment of satisfactory young stands assumes increasing importance in view of the greatly diminished supply of merchantable timber of these two valuable species.

Aspen, while occupying a relatively minor role in current forest production in Ontario, occurs over tremendous territories stretching from east to west across the northern part of the Province. The species grows to large sizes with long clear trunks, and with increased intensity of utilization will undoubtedly be used more and more; in fact, there may be some difficulty in profitable operation of much of the northern forested area without taking advantage of the tremendous growth of this species during the first decades in the establishment of young stands, following former disturbance by cutting or fire. The stands of aspen are subject to attack periodically by the tent caterpillars and other defoliators and frequently severe damage results.

The other commercial timber species in Ontario are affected to a greater or lesser degree by forest insects: the hemlock by the hemlock looper; larch by the European larch sawfly; birch by the bronze birch borer; maple by the striped maple worm, the maple leaf cutter and other defoliators; and so on.

Forest entomological work in Ontario commenced soon after the establishment in 1911 of a Forest Insect Investigations Unit in the Dominion Department of Agriculture. Investigations of insects affecting nurseries, woodlots and shade trees in southern Ontario have been conducted more or less continuously from about 1915, from field stations established first at Aylmer, later at Merivale and more recently at Angus, and from time to time at other temporary establishments set up to serve the requirements of particular problems. During the first decade after the establishment of the Forest Insect Investigations Unit, investigations of insect problems in the northern forests consisted of inspections, general reconnaissance and some experimental studies in control of forest insects, generally being conducted from short-period summer establishments. Full seasonal studies were conducted in the Agawa Valley of the Algoma region (1924-1926) and similar seasonal camps were established at Welcome

Lake in the Sudbury district (1925), at Westree and in the Muskoka Lakes District (1928-1929) and near Biscotasing (1930-1931). In 1930 a permanent camp was established at Kipawa Lake, and this station has been developed progressively since that time with increasing attention being given to various insect problems in the North Bay - Timiskaming region of Ontario. In 1935 studies were commenced in the Chalk River area, attention being given particularly to insect pests affecting stands of pine and larch. The Chalk River establishment was put on a more permanent basis in 1937-1938 by the construction of a field laboratory at the headquarters site of the Petawawa Forest Experimental Station of the Dominion Forest Service. Starting in 1937 and continuing until 1945, forest insect problems in the extreme western part of Ontario were investigated by personnel of the Winnipeg Forest Insect Laboratory, seasonally located at Hawk Lake, near Kenora. In 1944, long-term investigations in the Lake Nipigon territory were started by personnel of the Sault Ste. Marie forest insect establishment, occupying quarters in a lumber camp near Black Sturgeon Lake, made available by the Great Lakes Pulp and Paper Company. This development was set on a more permanent basis in 1945 by the erection of a permanent building jointly by the Ontario Department of Lands and Forests and the Forest Insect Unit, on a suitable site made available through the former Department. Subsequent additions will be provided just as soon as circumstances permit.

In addition to the seasonal and more permanent establishments referred to in the preceding paragraph, numerous short-period studies have been carried out by various personnel of the Forest Insect Unit and frequently of the Department of Lands and Forests, working jointly and occupying short-period quarters in camps, tent establishments, etcetera. These will not be referred to specifically here because of the non-permanent or short-time interests served by such arrangements.

During the long interval covered by this general review, from 1911 onwards, comparatively few trained investigators were available for the large number of pressing problems, and consequently for the most part investigations were necessarily fragmentary and could not cover the range of the problem in the Province. Realization on the part of the Dominion Department of Agriculture and the Ontario Department of Lands and Forests of the deficiencies in the knowledge of forest insect problems which still persisted some thirty years after the initiation of forest entomological work in Ontario, lead, in 1945, to the enactment of a joint agreement between the two Departments whereby the latter provided a modern laboratory for forest entomology at Sault Ste. Marie, and the former undertook to equip it and staff it, on a sufficient scale to carry out effective forest insect surveys and investigational work, in the expectation that the desired degree of control may be exercised over insect depredations in the Ontario forests.

II

REVIEW OF FOREST INSECT INFESTATIONS IN ONTARIO.

There are a large number of native and foreign insect pests which are enemies of forest trees in Ontario. Some of these have been particularly destructive in recent years; others have occurred in outbreak form in the past but are not currently in the destructive phase. It is beyond the scope of this brief to review, in detail, all the known facts regarding any particular insect species, nor is it possible to mention even casually, all those species which are potential enemies of the forest. Therefore, in the discussion which follows, interest is necessarily restricted to the economic aspects of some of the most destructive pests, with an indication, in some cases, of the probable measures which may be taken for prevention or control of damage. Where such indications are not given, the inference is plain that much more research must be conducted before suitable recommendations can be made.

Spruce Budworm
(Archips fumiferana Clem.)

The spruce budworm is a notorious native species of North America, with possibly the most imposing history of destructive outbreaks of any North American forest insect. In various parts of the continent, biological forms which have been given specific rank in some instances, are adapted to different host species. The various forms include the form on balsam fir and spruce in eastern North America, the form on jackpine in the central part of the continent, the form on lodgepole pine in the western states, the form on Douglas fir and associated species of Abies and Picea in the region west of the Rocky Mountains. In this account, interest will be limited to the form attacking balsam fir and spruce in eastern North America. Volumes have been written describing the course of past and current outbreaks, and only a concise review will be attempted here.

The spruce budworm appears in early spring, April and May, as minute larvae which either bore into the old needles for a short period, or attack the newly opening buds of balsam fir, white spruce, red spruce and black spruce. During larval development the larvae feed successively on the newly opening buds, later on the growing needles of the expanding shoots, and ultimately, if forced to do so by food shortage, on the old foliage of the tree. At full growth, in June or July, the larvae transform to pupae on the twigs and the moths soon emerge to lay eggs for the next generation. These eggs hatch in July and August, and the young larvae establish themselves under silken shelters on the twigs for the winter months. Feeding does not take place until the following spring.

A general account of outbreaks in eastern Canada up to 1924 has been provided by Doctors J. M. Swaine and F. C. Craighead. (A) In 1909, an area of intensive infestation was discovered in the Province of Quebec north of Lake Baskatong, and this in succeeding years extended to take in a great proportion of the Quebec forested area from Lake Timiskaming in the west to the Saguenay River in the east, reaching down into New Brunswick, Maine and Cape Breton Island, 1914 - 1919. By 1919, the outbreak in the Province of Quebec was confined to an area surrounding Lac Expanse in the western portion of the province. This outbreak, by 1920, extended westward into Ontario, and the latter province has had a succession of budworm devastations more or less without interruption since that time.

The earliest published reference which has been discovered

A - Studies on the Spruce Budworm. J. M. Swaine and F. C. Craighead. Dominion Department of Agriculture Bulletin No. 37 n.s. Ottawa, 1924.

relative to the spruce budworm attacks in the Province of Ontario is that quoted by Swaine and Craighead. In the report of the Dominion Entomologist for 1914, reference is made to reduction of the intensity of the spruce budworm attack in Ontario (and Quebec) from the condition which had prevailed during the preceding three years. The portion of the Ontario forests infested by the spruce budworm at this time is not named. It is exceedingly doubtful however, whether this 1911-1914 infestation in Ontario was the first important infestation in the province. Preliminary evidence obtained by Mr. J. R. Blais of the Forest Insect Laboratory, Sault Ste. Marie, in 1946, suggests the occurrence of outbreaks in the Wabigoon section of the western region approximately 75 and 150 years ago. Much more intensive study however, will be necessary in this and other regions of the province before the various types of evidence can be assembled in a reasonably accurate history of these long past events.

The outbreak which appeared in the Timiskaming region of Ontario as an extension westward from the Province of Quebec, was in 1920, confined so far as was known, to the territory between Englehart in the north, and Timagami Reserve in the southwest. In 1921, there was a considerable extension westward taking in most of the territory between Lake Timiskaming and Lake Timagami in a medium to heavy infestation, and extending in light infestation as far as Gowganda in the west. By 1924, the infestation had spread still further to the south and west taking in the area around Meteor Lake, Thor Lake and Welcome Lake north of Sudbury on the Canadian National Railway line. The course of this infestation is unknown during the next two or three years, but by 1927 the infestation was still more extensive in the territory lying north and west of Sudbury with approximately 3800 square miles under heavy attack, the direction of movement apparently being to the west. It is also worthy of note that white spruce was, in 1927, undergoing severe attack in areas where balsam fir had been previously killed out. In 1928, the infestation was found as far west as Westree, north of Sudbury. In this area it was estimated that about one-half of the balsam fir timber in this area was dead, and another one-quarter in a dying condition. A light infestation was also found in Servos Township south of Sudbury, in 1928. In 1931, the attack had extended northward to the townships of Sheraton and Egan, east of Timmins, and the area of heavy attack in the south extended to the north shore of Georgian Bay. Light infestations extended as far west as Chapleau. This infestation in the Sudbury and North Bay Districts of Ontario was not followed accurately from 1931 on, and the course of events in the areas immediately following is unknown.

Meanwhile in 1925, a severe infestation was discovered in the vicinity of Lac des Mille Lacs in the Port Arthur District south

of Upsala. The origin of this infestation and its subsequent history are unreported.

About 1936, infestations of the spruce budworm became rampant in the Sault Ste. Marie and adjacent Districts of Ontario, and have subsequently spread to take in practically all of the territory between Lake Superior and the Quebec border, south to Algonquin Park, and north beyond Cochrane and Kapuskasing. In 1943, an extensive outbreak was discovered around Lake Nipigon, and this has subsequently enlarged, particularly to the east. In 1942, a very active infestation was found between Sioux Lookout and Hudson, and this has also shown a slight but progressive enlargement year by year. In 1945, a very extensive outbreak was discovered southwest of Lac Seul in the Sioux Lookout Forest District, and this has also shown considerable enlargement during the past year. The accompanying maps show in outline the approximate progress of these outbreaks, and further descriptive reference will therefore not be included here.

Attempts in the direct control of the spruce budworm by distribution of poisons from aircraft were carried out in Ontario and on Cape Breton Island. The Ontario operation was located at Westree in 1929. Calcium arsenate dust was released from a Ford tri-motor plane capable of carrying nearly one ton of dust. Dusting operations were carried out the latter part of June, applications ranging from thirty to forty pounds per acre. Subsequent counts of larval mortality indicated a mortality of less than 50%, and it was concluded that the spruce budworm was exceedingly difficult to kill by the application of poison dust. This is presumably due to the habit of feeding inside a cluster of needles. Furthermore, the poison dust was very liable to be washed off by rain before it could have lethal effects.

In some recent years, attempts to control the spruce budworm by poisons distributed from aircraft have been carried out in Ontario using the new insecticide, D.D.T., which has been released in the form of oil solutions, at the rate of one to two pounds per acre of D.D.T. in one or two gallons of oil carrier. Results of these operations are described in a later section of this report in connection with investigational projects on the spruce budworm, to which the reader is referred.

Estimation on an adequate scale of the damage in Ontario caused by the outbreak of the spruce budworm, starting about 1936, has been entirely beyond the capacities of the staff of the Forest Insect Unit. However, a number of sample plots varying in size from about one-tenth to one-half an acre have been established and followed from year to year, and others have been laid out in 1946 in some of the more recently affected stands. In addition, a series of 107 cruise lines were run by a field party operating in the Algoma region in 1946.

None of these studies has been adequate for estimation of the total damage caused by the spruce budworm, even in any one district, but the results, nevertheless, do indicate the degree of damage in certain definite localities. Data obtained in the Algoma cruise of of 1946 are shown in synoptic form in connection with the investigative programme described in a later section of this report, and will not be referred to here. Summary results based on permanent sample plots in various parts of the province are shown in the accompanying tables. An approximate location of these sample plots is shown on the 1946 infestation map of the spruce budworm.

In an attempt to appraise the degree of damage brought about during the recent epidemic phase of the spruce budworm, and particularly in evaluating the significance of figures shown in the attached tables, it should be kept in mind that the outbreak has passed its peak in the eastern and southern portions of the province, while on the other hand, the outbreak is still very active, and in fact, becoming more intensive in certain of the northern and western districts. There is, moreover, a strong tendency for the full mortality which follows spruce budworm outbreaks, to be realized only some years after the insect has almost completely disappeared. In the Algonquin Park-Mattawa-North Bay-Timiskaming-Kipawa region, where mortality in 1946 in most plots, was over 50%, and in some cases, approaching 100% of the balsam fir, a considerable proportion of this mortality occurred in 1945 and 1946, even though the infestation has been on a relatively minor scale for the past two or three years. In the Cochrane-Kapuskasing section of the province, mortality is still relatively light and whether it will subsequently rise to serious proportions will depend upon the duration and severity of the attack in those territories. In the Port Arthur district and the Sioux Lookout district, the infestations are still comparatively recent, and the effects of the defoliation are, for the most part, just beginning to be reflected in mortality of balsam fir and white spruce. How far the process will continue cannot be stated with any assurance, but there is no ground for optimism in the present state of vigour of the infestations.

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.		Bulworm Hosts	% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13+	% age Mortality by Volume
1	Algonquin Park Highway Mile 5 - 6	4220	1208	20	Bf	1612	100	100	100	-	-	100
					Sw	1372	-	-	-	-	100	100
					Sb	8	0	0	-	-	-	0
2	Algonquin Park Highway Mile 6 - 7	7803	2992	1747	Bf	3008	65	88	100	100	-	27
					Sw	56	-	-	-	-	-	0
					Sb	-	-	-	-	-	-	-
3	Algonquin Park Highway Mile 5	1382	111	114	Bf	1020	98	100	100	-	-	99
					Sw	98	20	60	-	-	-	60
					Sb	39	0	0	0	-	-	0
4	Algonquin Park Highway Mile 4 - 5	958	0	65	Bf	764	0	0	0	0	-	0
					Sw	125	0	0	0	-	-	0
					Sb	4	0	-	-	-	-	0
5	Algonquin Park Tea Lake Dam	2154	265	1	Bf	1838	46	55	36	-	-	47
					Sw	50	0	0	-	-	-	0
					Sb	-	-	-	-	-	-	-
6	Algonquin Park Highway Mile 5 - 6	3665	263	169	Bf	693	4	100	86	-	-	82
					Sw	-	-	-	-	-	-	-
					Sb	2540	20	20	11	-	67	28

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Softwoods Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13+	%age Mortality by Volume
7	Algonquin Park Highway Mile 4	2852	5	872	Bf	1242	99	100	100	100	-	100
					Sw	730	80	33	-	-	100	97
					Sb	3	0	-	-	-	-	0
8	Algonquin Park Oxtongue River Camp 4	180	24	14	Bf	1144	66	64	81	100	-	65
					Sw	-	-	-	-	-	-	-
					Sb	619	50	0	0	50	-	26
9	Algonquin Park Highway	1352	190	6	Bf	1141	0	0	0	0	0	0
					Sw	15	0	0	-	-	-	0
					Sb	-	-	-	-	-	-	-
10	Algonquin Park Headquarters	3097	625	455	Bf	1704	55	46	75	100	100	71
					Sw	203	0	0	0	-	-	0
					Sb	110	0	0	0	-	-	0
11	Mattawa Aumond Lake Road	3064	0	55	Bf	75	0	50	-	-	-	38
					Sw	2453	71	26	27	-	-	31
					Sb	481	(100)	(33)	0	(100)	0	34
12	Mattawa Craig Lake	1924	0	22	Bf	1900	100	100	-	-	-	100
					Sw	1	0	-	-	-	-	0
					Sb	1	0	-	-	-	-	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volumes Per Acre (Cu.Ft.)					% age of Stems Killed By Diameter Class					% age Mortal By Volum
		Total	Hardwood	Softwoods Misc.	Budworm Hosts		1 - 3	4 - 6	7 - 9	10 - 12	13+	
13	Mattawa - Craig Lake Road	3185	368	20	Bf	1786	100	100	93	100	100	97
					Sw	651	67	40	33	-	-	12
					Sb	360	-	100	100	67	-	67
14	Mattawa - Craig Lake Road	4355	1386	276	Bf	1980	98	98	50	-	100	94
					Sw	574	80	58	-	-	-	29
					Sb	139	100	50	-	-	-	44
15	Mattawa - Craig Lake Road	3549	1640	9	Bf	1889	99	96	100	-	-	98
					Sw	0	-	-	-	-	-	-
					Sb	12	-	100	-	-	-	100
16	Little Jocko River Ontario.	1755	172	4	Bf	1557	64	35	42	60	100	80
					Sw	0	-	-	-	-	-	-
					Sb	21	17	0	0	0	0	1
17	Little Jocko River, Ontario.	2026	0	438	Bf	89	0	33	-	-	-	23
					Sw	0	-	-	-	-	-	-
					Sb	1499	50	9	23	17	-	26
18	Big Jocko River, Ontario.	881	237	0	Bf	454	3	0	0	-	-	1
					Sw	0	-	-	-	-	-	-
					Sb	191	4	0	1	1	1	0.1

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Misc.	Softwoods Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality by Volume
19	White Creek, P.Q.	2508	639	524	Bf	1159	95	80	60	67	-	76
					Sw	--	-	-	-	-	-	--
					Sb	186	0	0	0	0	0	0
20	Gagnon's Creek, P.Q.	1551	56	--	Bf	1499	100	100	82	100	-	92
					Sw	--	-	-	-	-	-	--
					Sb	16	-	0	-	-	-	0
21	Lac Kipawa, P.Q.	2779	264	2033	Bf	481	28	14	0	20	-	14
					Sw	--	-	-	-	-	-	--
					Sb	--	-	-	-	-	-	--
22	MacKenzie Island Lac Kipawa, P.Q.	1530	299	790	Bf	348	51	19	50	-	-	36
					Sw	52	0	0	0	0	0	0
					Sb	41	0	0	0	0	0	0
23	Dirty Bay Lac Kipawa, P.Q.	2426	1732	218	Bf	233	18	57	-	-	-	40
					Sw	--	-	-	-	-	-	--
					Sb	243	0	25	0	-	-	13
24	Dirty Bay Lac Kipawa, P.Q.	1527	61	339	Bf	968	93	93	100	-	-	94
					Sw	113	0	0	0	0	0	0
					Sb	47	0	0	0	0	0	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.		Budworm Hosts	Age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	Mortality by Volume
25	Dirty Bay Lac Kipawa, P.Q.	2090	947	205	Bf	927	80	51	-	-	-	74
					Sw	9	0	0	0	0	0	0
					Sb	2	0	0	0	0	0	0
26	Timagami, Ontario	941	56	98	Bf	690	52	50	43	-	-	54
					Sw	9	0	0	0	0	0	0
					Sb	88	0	0	50	-	-	27
27	Timagami, Ontario	1701	172	633	Bf	787	74	65	100	-	-	70
					Sw	-	-	-	-	-	-	--
					Sb	110	-	50	100	-	-	82
28	Bannockburn Township North Bay District	2108	385	773	Bf	775	11	16	33	67	-	26
					Sw	44	0	0	0	-	-	0
					Sb	131	0	25	25	0	-	15
29	Ranger Lake Road Mile 10½ Sault Ste. Marie District	3943	3074	596	Bf	164	18	0	0	-	-	.02
					Sw	108	0	-	-	-	-	0
					Sb	-	-	-	-	-	-	--
30	Ranger Lake Road Mile 11 Sault Ste. Marie District	2252	1120	62	Bf	852	4	0	0	25	0	12
					Sw	217	0	0	0	0	-	0
					Sb	--	-	-	-	-	-	--

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13+	% age Mortality By Volume
31	Ranger Lake Road Mile 12-Sault Ste. Marie District.	3589	1209	511	Bf	503	19	10	33	-	-	25
					Sw	1054	0	0	0	0	0	0
					Sb	312	-	[illegible]	0	0	-	4
32	Ranger Lake Road Mile 12 Sault Ste. Marie District	1514	73	33	Bf	1146	4	5	12	-	-	6
					Sw	0	-	-	-	-	-	-
					Sb	262	0	0	0	-	-	0
33	Ranger Lake Road Mile 13, Sault Ste. Marie District.	2032	164	0	Bf	1657	11	25	24	11	-	18
					Sw	211	0	-	0	0	-	0
					Sb	0	-	-	-	-	-	-
34	Ranger Lake Road Mile 14, Sault Ste. Marie District	1946	221	38	Bf	1629	19	4	7	20	-	9
					Sw	58	25	0	0	-	-	1
					Sb	0	-	-	-	-	-	-
35	Ranger Lake Road Mile 14, Sault Ste. Marie District.	4379	1910	1435	Bf	645	29	25	0	0	50	24
					Sw	389	0	0	0	0	0	0
					Sb	0	-	-	-	-	-	-
36	Ranger Lake Road Mile 14, Sault Ste. Marie District	1908	411	18	Bf	1210	7	2	0	0	-	1
					Sw	169	0	0	0	0	-	0
					Sb	100	12	0	-	-	-	0.1

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		Volume	%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13+	%age Mortality By Volume
37	Ranger Lake Road, Mile 20-Sault Ste. Marie District.	984	46	51	Bf	740		30	60	87	-	-	72
					Sw	147		11	0	0	0	-	1
					Sb	0		-	-	-	-	-	-
38	Ranger Lake Road, Mile 20-Sault Ste. Marie District.	2015	1106	113	Bf	615		17	5	12	-	-	10
					Sw	181		-	0	-	0	-	0
					Sb	0		-	-	-	-	-	-
39	Ranger Lake Road, Mile 21-Sault Ste. Marie District.	5832	176	4756	Bf	601		21	29	100	100	-	69
					Sw	244		9	0	0	0	-	1
					Sb	55		0	0	100	-	-	71
40	Ranger Lake Road, Mile 22-Sault Ste. Marie District.	5152	162	4053	Bf	359		27	43	75	-	-	58
					Sw	578		0	25	0	33	0	21
					Sb	0		-	-	-	-	-	-
41	Ranger Lake Road, Mile 23-Sault Ste. Marie District.	2523	3	0	Bf	447		13	71	67	100	-	69
					Sw	26		-	-	0	-	-	0
					Sb	2047		9	17	0	33	0	11
42	Prairie Grass Lake Sault Ste. Marie District.	3007	371	167	Bf	1339		98	100	100	-	-	100
					Sw	522		0	-	50	0	-	57
					Sb	608		0	0	0	20	-	39

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13+	%age Mortality By Volume
43	Prairie Grass Lake Sault Ste. Marie Dist.	4086	934		1236	Bf	1916	94	98	100	100	-	99
						Sw	0	-	-	-	-	-	-
						Sb	0	-	-	-	-	-	-
44	ACR Mile 50 - Sault Ste. Marie Dist.	1877	22		43	Bf	1334	44	8	50	25	-	25
						Sw	150	100	0	0	0	0	1
						Sb	328	7	9	20	0	0	18
45	ACR Mile 52-Sault Ste. Marie Dist.	1647	257		3	Bf	1076	25	22	8	75	-	51
						Sw	34	0	0	0	0	0	0
						Sb	278	7	9	0	0	0	3
46	ACR Mile 50-Sault Ste. Marie Dist.	3477	1120		1574	Bf	783	29	50	54	0	-	51
						Sw	1	0	-	-	-	-	0
						Sb	0	-	-	-	-	-	-
47	ACR Mile 92-Sault Ste. Marie Dist.	3976	2560		481	Bf	433	0	0	0	0	0	0
						Sw	502	0	0	0	0	0	0
						Sb	0	-	-	-	-	-	-
48	ACR Mile 92-Sault Ste. Marie Dist.	2652	366		4	Bf	1149	29	20	20	0	0	11
						Sw	1127	17	0	25	33	0	16
						Sb	6	0	0	0	0	0	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Misc.	Budworm Hosts		Age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13	Age Mortality by Volume
49	Tikamaganda Lake Twp. Range 18 Sault Ste. Marie District	1752	341	190	Bf	222	50	76	30	50	100	76
					Sw	471	16	13	0	67	38	42
					Sb	397	5	3	8	7	20	10
50	A.C.R. Mile 138 Sault Ste. Marie District	5083	1308	1947	Bf	677	62	54	50	100	-	63
					Sw	1079	33	0	25	0	0	5
					Sb	72	100	0	0	0	0	1
51	Sand Lake, A. C. R. Sault Ste. Marie District	942	33	2	Bf	472	91	100	100	-	-	97
					Sw	231	31	0	0	0	-	1
					Sb	197	0	0	0	0	-	0
52	A. C. R. Mile 192 Sault Ste. Marie District	2490	1276	19[illegible]	Bf	764	30	65	63	100	0	72
					Sw	132	0	0	0	0	0	0
					Sb	123	8	0	0	0	0	1
53	A. C. R. Mile 19[illegible] Sault Ste. Marie District	3586	880	167	Bf	1942	83	80	88	50	-	86
					Sw	333	100	33	0	50	-	34
					Sb	261	0	0	0	0	-	0
54	Abitibi Lake Parvis Twp. Cochrane District	1689	-	110	Bf	794	[illegible]	2	22	0	-	13
					Sw	295	-	20	-	-	0	2
					Sb	490	50	6	14	0	-	8

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volume Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Softwoods Budworm Hosts		% age of Items Killed By Diameter Classes 1 - 3	4 - 6	7 - 9	10-12	13+	% age Mortality By Volume
55	Bowyer Twp. Cochrane Dist.	1171	126	-	Bf	769	4	1	0	-	-	1
					Sw	4	0	0	-	-	-	0
					Sb	272	0	5	0	0	-	3
56	St. John Twp. Cochrane Dist.	1709	12	-	Bf	731	4	8	63	-	-	14
					Sw	-	-	-	-	-	-	-
					Sb	966	5	9	14	30	-	21
57	Robb Twp. Cochrane Dist.	2046	778	-	Bf	1019	15	2	0	-	-	6
					Sw	211	0	0	0	0	-	0
					Sb	38	0	0	-	-	-	0
58	Homuth Twp. Cochrane Dist.	1783	349	-	Bf	1339	6	1	0	-	-	1
					Sw	95	0	33	40	-	-	39
					Sb	-	-	-	-	-	-	-
59	Pearce Twp. Kapuskasing Dist.	4603	3130	-	Bf	1222	4	10	7	-	-	9
					Sw	234	14	23	0	-	-	7
					Sb	17	-	0	-	-	-	0
60	Saganash Lake Staples Twp. Kapuskasing Dist.	3046	868	438	Bf	1409	25	5	8	-	-	7
					Sw	319	75	0	0	0	-	1
					Sb	12	0	0	-	-	-	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% Age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13+	% Age Mortality by Volume
61	Orkney Township Kapuskasing District	5735	1539	-	Bf	1579	49	8	12	0	0	12
					Sw	2271	80	60	40	4	0	7
					Sb	347	0	71	12	-	-	16
62	Franz Township Kapuskasing District	5821	1690	-	Bf	3860	46	13	14	8	(100)	14
					Sw	266	0	-	-	-	0	0
					Sb	5	-	0	-	-	-	0
63	Clavet Township Kapuskasing District	3734	2518	108	Bf	455	21	3	(100)	-	-	12
					Sw	436	26	0	0	-	-	2
					Sb	127	22	0	-	-	-	4
64	South of Bell Township Geraldton District	2741	943	-	Bf	806	0	3	0	(100)	-	6
					Sw	750	0	0	0	0	0	0
					Sb	242	25	0	0	-	(100)	74
65	Lower Twin Lakes Nettleton Township Geraldton District	2370	171	497	Bf	804	0	3	10	-	-	8
					Sw	313	0	0	0	(100)	-	23
					Sb	585	(100)	38	10	(100)	-	23
66	Legault Township Geraldton District	2020	1267	107	Bf	350	0	0	-	-	-	0
					Sw	73	0	-	-	0	-	0
					Sb	223	0	0	0	0	-	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Softwoods Budworm Hosts	%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality By Volume
67	Jellicoe Twp. Geraldton Dist.	3150	196	-	Bf 2673	14	10	9	-	-	10
					Sw -	-	-	-	-	-	-
					Sb 281	0	0	0	-	-	0
68	Roslyn Lake Geraldton Dis.	4245	2126	-	Bf 981	59	29	0	-	-	19
					Sw 1070	-	50	0	0	0	3
					Sb 68	-	-	0	-	-	0
69	Barbara Lake Port Arthur Dis.	2748	481	-	Bf 1568	39	18	40	0	-	2
					Sw 300	0	0	0	0	-	0
					Sb 400	(100)	0	0	0	0	1
70	Georgia Lake (S.E. shore) Port Arthur Dist.	4033	908	-	Bf 1182	11	1	0	-	-	3
					Sw 1367	20	-	-	-	0	0.1
					Sb 576	0	0	0	0	-	0
71	Georgia Lake (North Shore) Port Arthur Dist.	3678	485	30	Bf 1620	67	45	15	40	-	30
					Sw 1008	22	20	6	6	20	12
					Sb 535	25	10	0	0	-	1
72	Beardmore Port Arthur Dist.	2754	1256	-	Bf 1092	19	7	0	-	-	5
					Sw 167	0	25	33	-	-	24
					Sb 239	-	0	0	-	-	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot Number	Locality	Volume Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality By Volume
73	N.E. Macdiarmid Twp Port Arthur Dist.	5422	1690	1003	Bf	945	47	26	33	-	-	31
					Sw	941	-	25	14	0	-	7
					Sb	843	100	33	9	50	-	22
74	Macdiarmid Twp. Port Arthur Dist.	3116	72	-	Bf	2708	63	21	8	50	-	18
					Sw	112	-	-	-	0	-	0
					Sb	224	0	-	-	0	-	0
75	N. of Shilabeer Lk. Port Arthur Dist.	3402	19	-	Bf	1224	33	46	7	0	-	17
					Sw	145	0	-	-	0	-	0
					Sb	2015	0	14	33	0	0	7
76	W. of Nonwatin Lk. Port Arthur Dist.	3388	2120	689	Bf	375	(100)	8	0	-	-	5
					Sw	135	7	33	0	-	-	18
					Sb	69	-	-	0	-	-	0
77	Disraeli Lake Port Arthur Dist.	5685	606	789	Bf	2746	33	10	5	11	67	22
					Sw	1544	0	-	0	-	20	19
					Sb	-	-	-	-	-	-	-
78	Disraeli Lake Port Arthur Dist.	4480	1345	67	Bf	2092	32	15	6	-	-	12
					Sw	975	0	0	0	0	-	0
					Sb	-	-	-	-	-	-	-

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality by Volume
79	South of Black Sturgeon Lake Port Arthur District	5455	1794	–	Bf	1330	53	10	5	22	(50)	16
					Sw	1910	100	75	50	33	27	50
					Sb	421	–	43	22	0	0	11
80	Chief Bay, Lake Nipigon Port Arthur District	3896	335	–	Bf	2589	100	79	63	75	0	59
					Sw	972	100	0	0	29	–	19
					Sb	–	–	–	–	–	–	–
81	Gull Bay, Lake Nipigon Port Arthur District	3212	511	45	Bf	1174	43	21	13	–	–	23
					Sw	113	0	–	–	–	0	0
					Sb	369	8	–	0	33	–	30
82	Gull Bay, Lake Nipigon Port Arthur District	5198	196	1753	Bf	2216	91	84	76	67	–	76
					Sw	1034	(62)		0	0	0	1
					Sb	–	–	–	–	–	–	–
83	Gull Bay, Lake Nipigon Port Arthur District	5516	2055	–	Bf	3462	40	21	19	54	67	45
					Sw	–	–	–	–	–	–	–
					Sb	–	–	–	–	–	–	–
84	Wabinosh Lake, Lake Nipigon Port Arthur District	4184	352	–	Bf	1397	24	0	0	–	–	15
					Sw	1724	0	–	0	0	–	0
					Sb	712	0	0	0	0	–	0

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10-12	13	%age Mortality by Volume
85	Wabinosh Lake, Lake Nipigon Port Arthur District	4407	2340	-	Bf	1893	23	7	0	(100)	-	9
					Sw	241	-	50	0	(100)	-	12
					Sb	23	0	0	-	-	-	0
86	Obonga Lake, (west end) Port Arthur District	3657	229	308	Bf	1695	68	20	0	0		8
					Sw	900	-	-	0	0	0	0
					Sb	524	0	0	0	-	-	0
87	Obonga Lake (west end) Port Arthur District	3164	814	-	Bf	2263	77	11	0	0	-	5
					Sw	58	0	-	0	0	-	0
					Sb	-	-	-	-	-	-	-
88	Garden Lake Port Arthur District	2606	647	-	Bf	1826	22	12	5	0		
					Cw	-	-	-	-	-	-	-
					Sb	223	0	0	50	0	-	15
90	Italian Peninsula Lost Lake Sioux Lookout District	1294	324	8	Bf	584	24	4	0	-	-	6
					Sw	115	50	50	50	-	-	50
					Sb	263	33	50	0	0	-	26

1946 SUMMARY OF MORTALITY IN SPRUCE BUDWORM SAMPLE PLOTS

Plot No.	Locality	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		%age of Stems Killed By diameter class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality by Volume
91	Italian Peninsula Lost Lake Sioux Lookout District	913	189	28	Bf	446	50	65	86	-	-	72
					Sw	199	22	42	14	-	-	27
					Sb	51	0	0	0	-	-	0
92	Italian Peninsula Lost Lake Sioux Lookout District	1220	397	8	Bf	415	72	89	37	-	-	65
					Sw	267	50	22	25	0	-	20
					Sb	133	0	0	0	-	-	0
93	Italian Peninsula Lost Lake Sioux Lookout District	1345	628	34	Bf	601	36	56	0	(100)	-	48
					Sw	79	0	0	0	-	-	0
					Sb	3	0	-	-	-	-	0
94	Italian Peninsula Lost Lake Sioux Lookout District	1156	527	8	Bf	320	50	64	-	-	-	62
					Sw	266	(50)	0	0	(50)	-	18
					Sb	35	-	0	0	-	-	0
95	Big Canon Lake (East shore) Kenora District	4607	580	2234	Bf	869	15	1	0	-	-	2
					Sw	-	-	-	-	-	-	-
					Sb	924	0	0	0	0	-	0

Jackpine Budworm

(Archips fumiferana Clem) *

Outbreaks of budworms on eastern coniferous trees had been experienced for several decades in the 20th century before any attack was evident on jackpine. In the mid 1930's, however, jackpine became infested by a budworm, exhibiting certain developmental and behaviour characteristics distinguishing this form from the spruce budworm previously known, and in the succeeding years attacks in jackpine stands became more frequent and more widespread. The insect is now generally distributed through jackpine stands in Ontario, Manitoba, Saskatchewan and the north central states. The species is unquestionably a native American species, and almost certainly developed from the spruce budworm or from a common progenitor of the two.

The method of attack is so similar to that of the spruce budworm, which has already been reviewed, that repetition will be avoided here. Certain differences have been observed among which may be cited the strong preference for jackpine, although white and red pine and black spruce, when occurring in mixture with jackpine, are attacked to a lesser degree. The insect also differs in colour and seasonal development, being, on the average, about a fortnight later than the spruce budworm. In intensive studies which have been carried on in the northern United States and in Ontario and Manitoba, it has been found that the attack is heaviest on jackpine trees bearing heavy crops of male flowers. The larvae were found in great abundance devouring the pollen early in the season, and this highly nutritious food has proven to be of considerable importance in the ability of the larvae to grow rapidly with high survival. There is evidence, also, that access to this type of food during at least part of the developmental stage has an important influence on vigour of the adult population.

The first appearance of the jackpine budworm in Ontario is not known with certainty, but in 1936 a heavy outbreak developed in the vicinity of Dogtooth Lake and Beaubien Lake in the Kenora district. In subsequent years the outbreak extended variously through the Kenora, Fort Frances, Sioux Lookout and Port Arthur forest districts, occassionally showing a measure of subsidence, then becoming resurgent once more in a more or less unpredictable manner. (See attached maps). The incursion of the infestation into the Port Arthur district was temporary, and the infestations in the southern portion of the western region began to subside generally in 1943, and had virtually disappeared by 1945. It was, therefore, a matter of considerable concern that, in 1945, a very active outbreak was discovered in the Sioux Lookout district west of Red Lake, in an area not previously reported to be infested.

* This form hitherto indistinguishable from the spruce budworm has been given thorough taxonomic study recently, and a distinctive scientific name will, no doubt, be available in the near future.

Jackpine Budworm Infestations

Western Region of Ontario

1936 - 1946

Legend

Areas of Infestations of varying intensity:

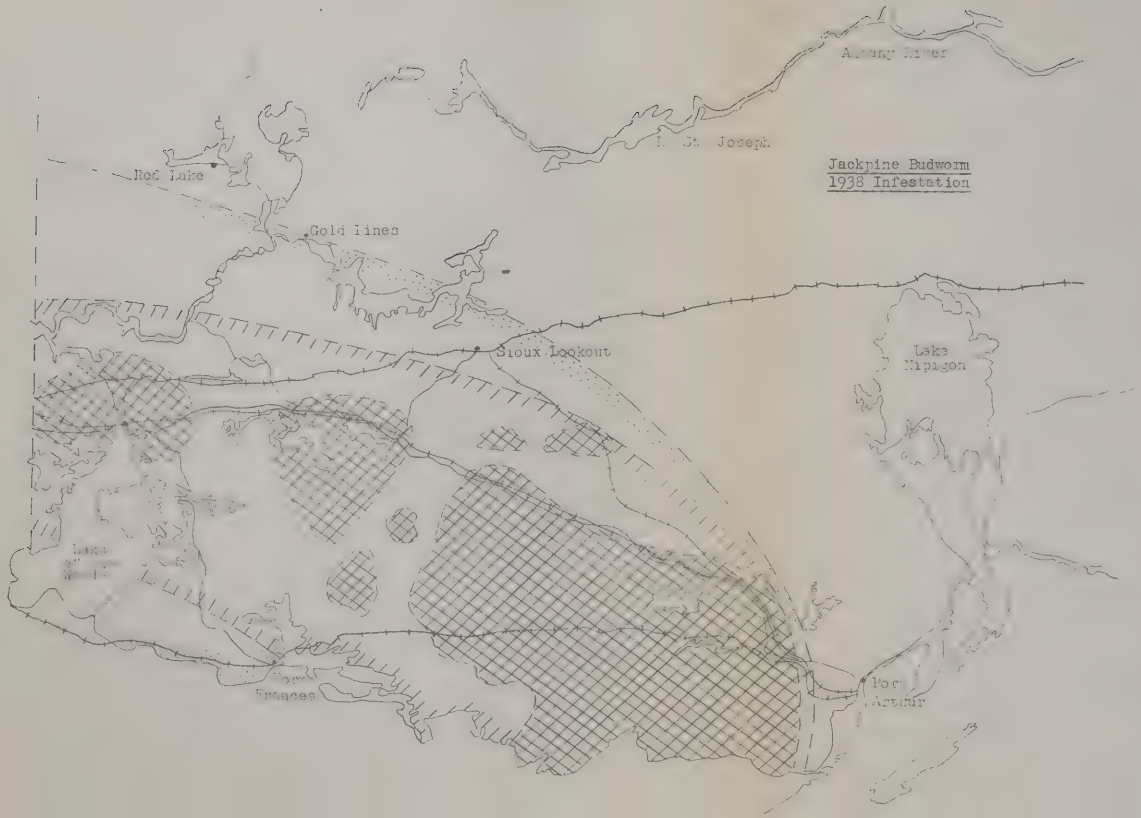
Light (approximate boundaries)..... 

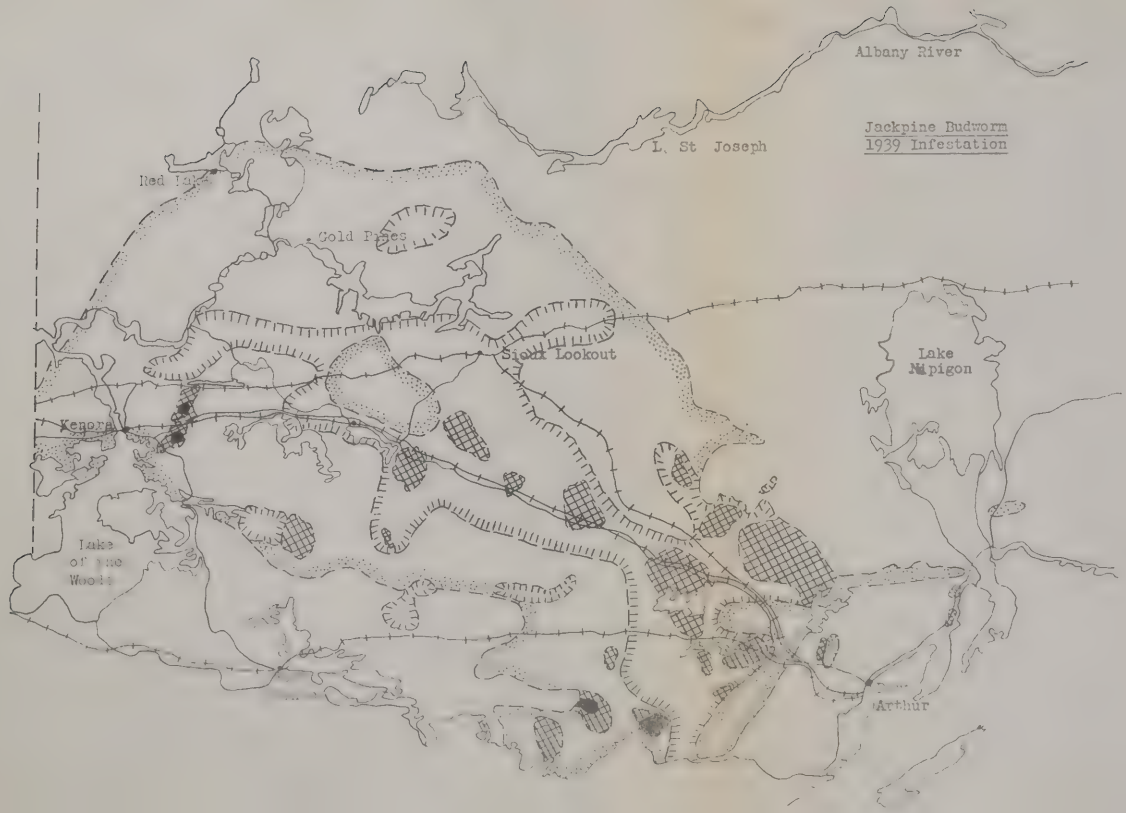
Medium (approximate boundaries).....

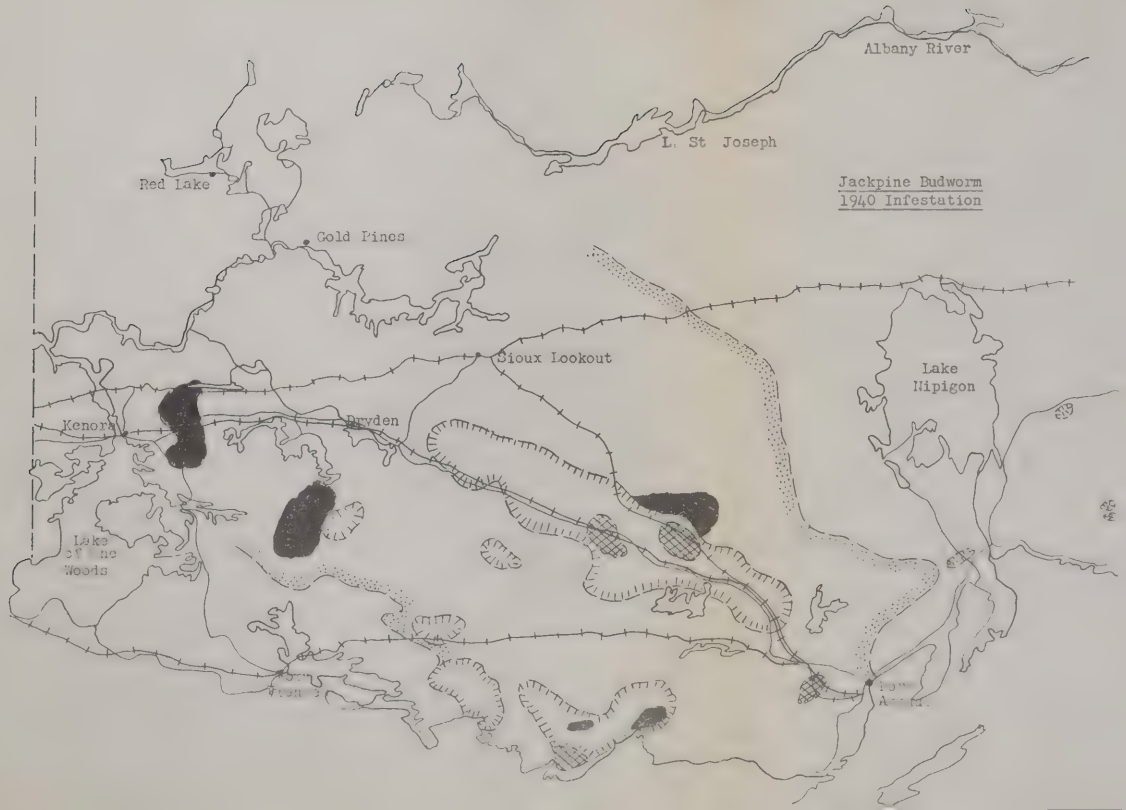
Heavy (areas affected)..... 

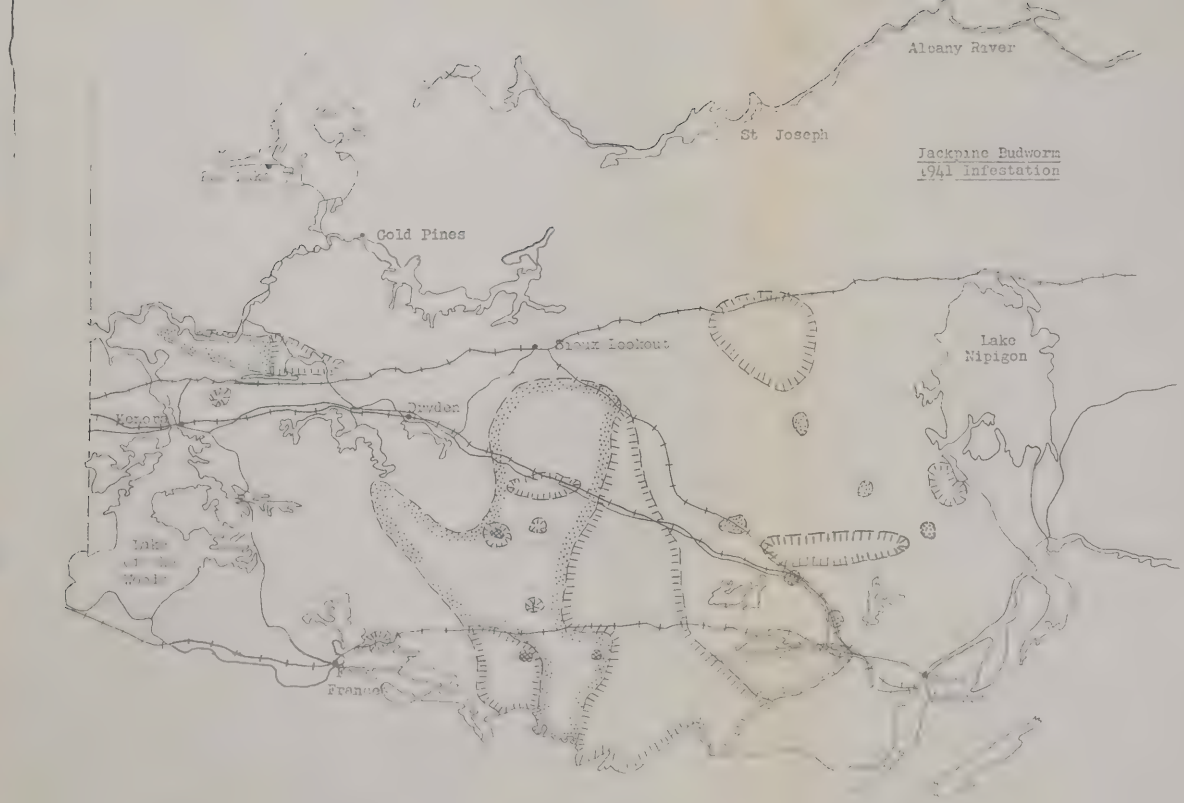
Areas where mortality of jackpine has resulted from infestations..... 

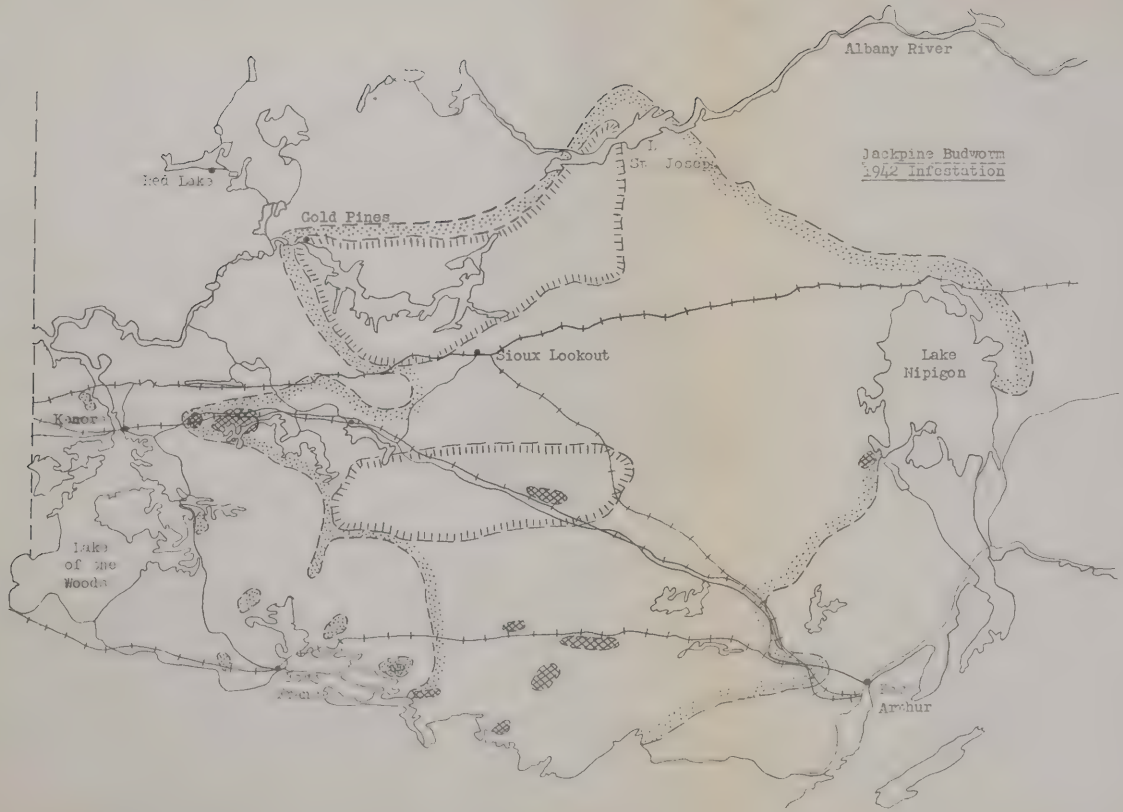

Albany River
L. St. Joseph
Red Lake
Gold Pines
Jackpine Budworm
1936 Infestation
Sioux Lookout
Lake
Nipigon
Kenora
Dryden
Lake
of the
Woods
Fort
Frances
Fort
Arthur

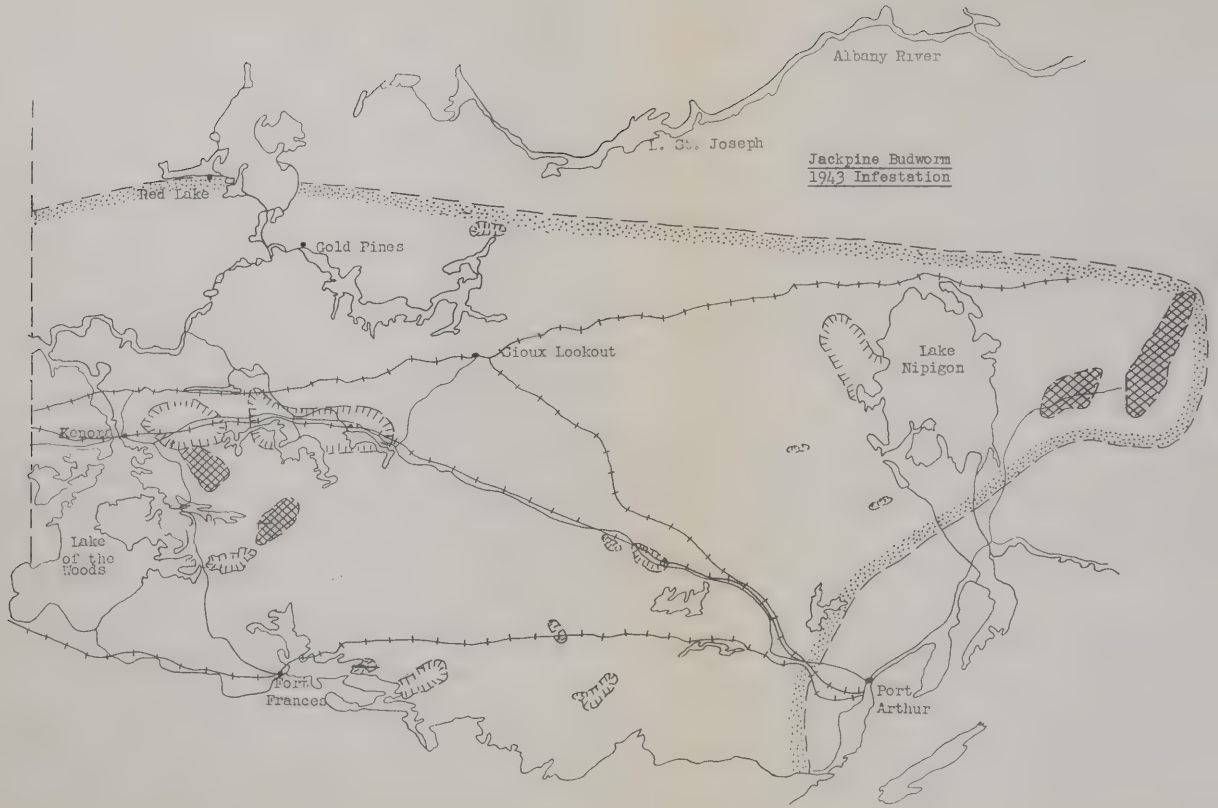

Albany River
L. St. Joseph
Red Lake
Gold Lines
Sioux Lookout
Lake Nipigon
Port Arthur
Jackpine Budworm
1938 Infestation

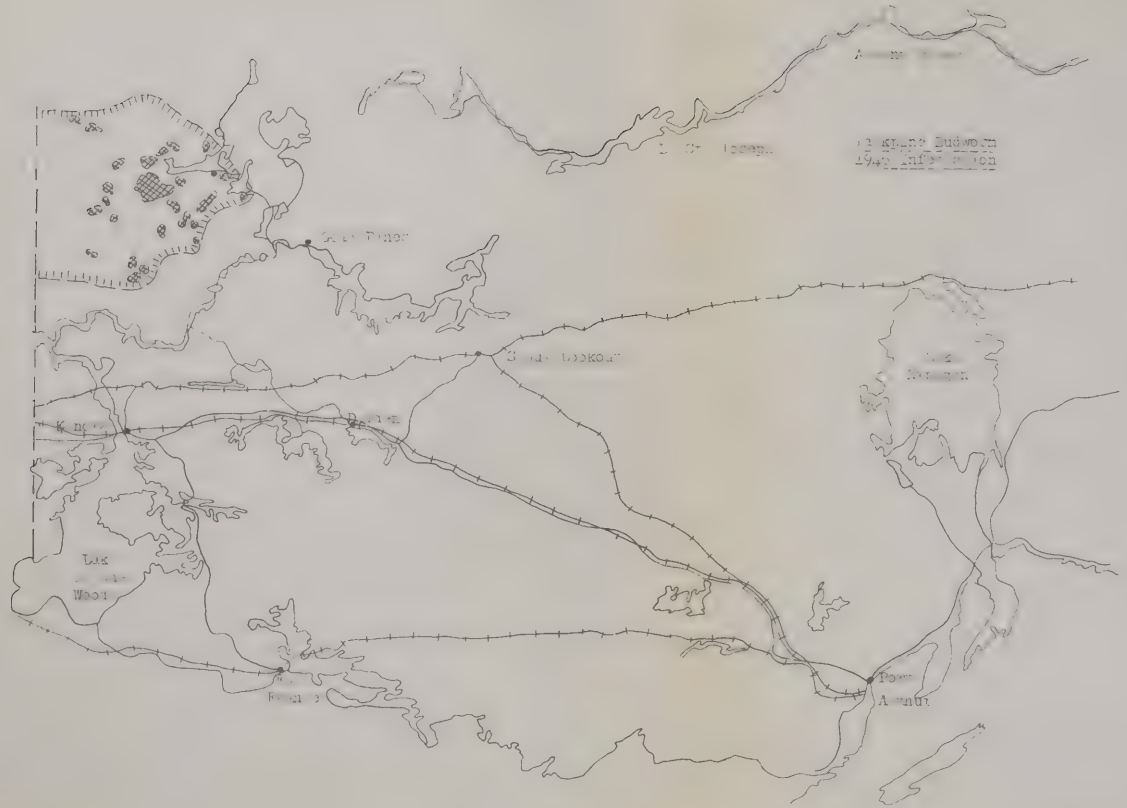

Albany River
Jackpine Budworm
1939 Infestation
L. St Joseph
Red Lake
Gold Pines
Sioux Lookout
Lake
Nipigon
Kenora
Lake
of the
Woods
Arthur


Albany River
L. St Joseph
Red Lake
Gold Pines
Sioux Lookout
Lake
Nipigon
Kenora
Dryden
Lake
of the
Woods
Jackpine Budworm
1940 Infestation


Albany River
St Joseph
Jackpine Budworm
1941 Infestation
Cold Pines
Sioux Lookout
Lake
Nipigon
Dryden
Kenora
Lake
of the
Woods
Fraser


Albany River
Jackpine Budworm
1942 Infestation
Red Lake
Cold Pines
St. Joseph
Sioux Lookout
Lake
Nipigon
Kenora
Lake
of the
Woods
Fort
Arthur


Albany River
L. St. Joseph
Jackpine Budworm
1943 Infestation
Red Lake
Cold Pines
Sioux Lookout
Lake
Nipigon
Kenora
Lake
of the
Woods
Fort
Frances
Port
Arthur



Moderate infestations of the jackpine budworm have occurred farther east in Ontario, for example in the vicinity of Franz in 1941, but these infestations disappeared within a year or two without serious damage. In 1946 the only active infestation of the jackpine budworm in Ontario, apart from the Sioux Lookout infestation, was found in the vicinity of Sultan, southeast of Chapleau on the Canadian Pacific Railway, where some twenty to twenty-five square miles were lightly infested, and the heavy infestation was concentrated in an area of approximately one square mile, or less, just north of Sultan.

Extensive studies of natural control factors operating against the jackpine budworm have been carried out by personnel of the Winnipeg Forest Insect Laboratory in the Kenora district. Particular attention was given to parasitism in the pupal stage of the insect where the highest degree of control by parasites was evident. A brief summary of the major findings of this long continued project is included in the succeeding synopsis.

YEAR	HAWK LAKE, ONTARIO	VARIOUS POINTS ONTARIO - MANITOBA
1937	12.3%	
1938	41.1%	
1939	47.2%	48.7%
1940	17.1%	15.3%
1941	13.9%	31.2%
1942	24.5%	
1943	11.7%	

In some localities, pupal parasitism accounted for somewhat higher proportions than those shown above, but it was generally concluded that neither parasites attacking eggs, nor the larval, nor pupal stage were sufficient in themselves to terminate the outbreaks. Evidence was also obtained that the highest mortality in the developmental period of the jackpine budworm occurred just at the time of issuance of the young larvae from hibernation, before they became established in the terminal growth, or in the opening flower cones. There was also some indication that the population levels of the jackpine budworm in the Kenora district were related to the abundance of flower production on the jackpine trees from year to year, although correlation between these two variables was by no means exact.

A co-operative field survey of the Ontario Department of Lands and Forests and of the Winnipeg staff of the Forest Insect Unit was carried out in 1939 to determine the consequences in terms of killed timber, and destroyed tops of jackpine, resulting from jackpine outbreaks which had been in progress for several years. Such surveys were carried out in a series of localities chosen to represent areas differing in infestation history. A synoptic review of the general findings of this survey, taken from a special report prepared by H. A. Richmond in 1939 to 1940, is shown in the accompanying table.

Summary of Damage Caused by Jackpine Budworm Infestations
in Western Region of Ontario

Infestations 1936 - 1939

Survey 1939

Infestation History	Locality	Damage	Site I	Site II	Site III	Site IV	All Sites
1936, severe	Dogtooth L.	% mortality	41	38	46	48	45
		% dead tops	3	2	2.5	3	--
	Beaubien L.	% mortality	-	62	57	52	55
		% dead tops	-	1.5	1	2	--
1936, severe others in 1937-1938	Waldhof Township	% mortality	4	14	12	8	11
		% dead tops	0	2	2	2	--
1936 and 1938, severe	Boat Island (Eagle L.)	% mortality	-	42	41	32	38
		% dead tops	-	1	0.3	1	--
	Osborne Bay (Eagle L.)	% mortality	24	23	31	30	30
		% dead tops	0	1	2	1	--
1936, 1937, 1938 and 1939 Infestations patchy	Dryden	% mortality	22	5	3	3	8
		% dead tops	-	-	-	-	--
	Butler	% mortality	1	3	3	4	2
		% dead tops	-	-	-	-	--
1937, apparently moderate 1939, severe	Raven L.	% mortality	-	-	-	-	1
		% dead tops	1	0.2	-	-	0.2

The greatest mortality occurred in that territory which was severely infested in 1936, with from 45 to 55 percent of the jackpine trees dead and dying. In the areas less severely defoliated in 1936, some of which also were re-infested in subsequent years, the degree of mortality was definitely less than in the Dogtooth-Beaubien Lake section, reaching the low point of less than one percent dead in the Raven Lake area, where there had been a moderate attack in 1937, followed by severe attack in 1939. In connection with this latter locality, however, it should be pointed out that the survey was made too close upon the defoliation of 1939 to measure accurately the consequences of the attack. It was, moreover, estimated that considerable mortality would result during the next year or two.

In 1939 examinations were also made at Northern Light Lake in the Fort Arthur district and at Kawnipi Lake in the Rainy River district where severe attacks had occurred in 1937. An ocular estimate in these two areas indicated about 30 percent mortality. No more recent general surveys have been made in the western region of Ontario to determine mortality subsequent to 1939 following upon the long protracted outbreak. Therefore, it would undoubtedly be conservative if H. A. Richmond's 1939 estimate of 15 percent mortality, over the affected area, were tentatively accepted.

Examination of a small plot (4/10th's acre) in a mixed stand consisting preponderantly of jackpine near Eva Lake in the Fort Frances district in 1946, disclosed mortality of 24 percent of the jackpine volume, distributed fairly generally throughout all diameter classes, although, mortality was exceptionally heavy in the one to three inch diameter class.

The general conclusion derived from long-term plot studies in the western region of Ontario, was that about 57 percent of jackpine trees that had lost approximately three quarter's or more of their foliage would subsequently succumb; but if secondary insects, such as the long-horned borers and certain species of bark beetles (eg. Ips pini) were particularly abundant, the proportion that would die from this degree of defoliation might be raised as high as 85 percent. In general, about 15 percent of the dying trees succumbed the same year they were heavily attacked. About 70 percent of the trees succumbed the year following attack. Ten percent succumbed the second year following attack, and smaller proportions in succeeding years.

About 90 percent of the dying jackpine trees were attacked by the secondary insects referred to above, and the borers attacked some 55 percent, thereby lessening the interest after death when profitable salvage could be carried out.

Destructive Eastern Spruce Bark Beetle
(Dendroctonus piceaperda Hopk.)

This insect is native to North America, and is found generally throughout the distribution of the eastern spruces. It has been recorded in numerous outbreaks of severe intensity in Canada, one of the most severe of these occurred in the Gaspe Peninsula from 1911 to 1918 when approximately forty five percent of the [illegible] spruce and small proportions of the black spruce, over very large territories were killed.

The species overwinters under the bark of attacked trees and windfalls, and adult beetles emerge in June or later to commence egg galleries under the bark of standing trees or windfalls. Two periods of attack are typical of this species: the first in June, and the second in July and August. In many cases, the insect will breed at a moderate rate in weakened timber or debris without becoming epidemic, but frequently the existence of large bodies of windfall or of white spruce timber weakened through the activities of defoliating insects or overmaturity, provides the basis for rapid population increase, and an active outbreak.

Comparatively little is known about the importance of the destructive eastern spruce bark beetle in Ontario forests. Several outbreaks have occurred, and considerable [illegible] near the mouth of the Agawa River in the early 1920's. Investigations in this area were carried on from 1924 to 1927 by officers of the Forest Insect Unit, particularly by E. B. Watson. The attack had evidently started in 1921 or 1922 as the result of extensive windthrow of white spruce in the low lying area between the Agawa River and MacGregor Cove, the high winds from the west over Lake Superior having been particularly destructive to the fine white spruce in this area. The beetle attack became [illegible] and 1924, and nearly [illegible] the white spruce were killed in an area of three to four square miles adjoining MacGregor Cove [illegible] percent in the area southward to the Montreal River. Although destruction of white spruce was most important in the mixed stands in low lying areas, even the scattered white spruce trees occurring in hard wood stands on the ridges were not immune. The occasional black spruce trees in the area, however, were not attacked by the beetle.

The trees which were killed by the beetles during the outbreak were representatively distributed throughout the diameter classes of the white spruce and were not selective of [illegible] classes. There was however, some evidence that the [illegible] trees in the various diameter classes were selected [illegible] Subsidence of the outbreak was traced to a combination of factors including (i) non recurrence of additional [illegible] (ii) the [illegible] down, to a large extent, the normal breeding [illegible] extensive activity of woodpeckers (principally the three toed Arctic three toed). The woodpeckers were active [illegible] bark of attacked trees during the winter months, and [illegible] broods of the bark beetle which overwinter under the bark. The woodpeckers were more efficient as control agents of the beetle populations in standing trees than in the case of windthrown trees, which are usually partly covered

with snow during the winter months, thereby providing a measure of protection to the beetle broods contained under the bark. An exception occurred, however, in the winter of 1925 to 1926 when snowfall was very light, and many of the attacked windfalls were exposed to woodpecker activity. In the closing years of the outbreak, the woodpeckers were estimated to have caused from 97 to over 99% control of the beetle, reducing its numbers to such an extent that there were insufficient beetles left to continue attack in the living timber.

The next evidence of the spruce bark beetles in Ontario occurred in 1938 when a light attack was evident near Eton on the A. C. R. in the Algoma region. In 1940, an infestation occurred at Connaught Lake, near Timmins, as well as at Wabigoon and Dryden. The insect remained in infestation near Timmins for several years, being still epidemic at Nighthawk Lake in 1942 and in 1943, but declining by 1944, although no estimates of mortality are available. Other infestations appeared in Gill and Studholme Townships west of Hearst in 1942, as well as at Remi Lake near Kapuskasing. In 1945 and 1946 a small number of large white spruce trees in mixed stands at Departure Lake, Sydere Township, near Smooth Rock Falls, were attacked by this beetle.

The occurrence of outbreaks of the eastern spruce bark beetle is generally to be construed as a definite indication of unmanaged forest; that is, either the existence of large quantities of overmature white spruce, weakened to a point where the trees are no longer resistant to attack, or to non-salvage of windthrown material, which can serve as a breeding centre to develop destructive populations. In the managed forest, the destructive spruce bark beetle will be of little economic importance. Until forests can be put under effective management, however, it should be possible to reduce damage to valuable white spruce stands by the spruce bark beetle by prompt cutting operations in any areas in which there is evidence of rising populations.

Hemlock Looper
(Lambdina fiscellaria Gn.)

The hemlock looper is a native North American insect which has caused destructive outbreaks in balsam fir and hemlock forests in the eastern portions of the Continent, and in western hemlock and Douglas fir forests in the Pacific coast regions. In outbreak conditions, the insects, however, frequently cause destruction of many other tree species than those which are their preferred hosts; for example, many deciduous trees may be stripped of their foliage as well as cedars when intermixed with the principal host species.

The species overwinters in the egg stage on the twigs and trunks of trees as well as on stumps and on the ground, and elsewhere in the affected stands. The young larvae appear in early summer and feed first on the foliage of their preferred host, but later during the summer are to be found on almost any food plant in the forest. The larvae are very wasteful feeders causing great destruction by nibbling through needle bases and even small twigs, thereby causing drying out of much foliage which they do not actually consume. The moths appear in August and September and deposit eggs more or less indiscriminately in the affected stands.

A number of outbreaks of rather limited proportions have occurred in Ontario. In 1902 - 1903 several islands in the Muskoka Lakes were severely infested, many trees were killed, but were apparently salvaged in a special cutting program. In 1925 hemlock trees were severely defoliated on an island in Gull Lake, Clarendon Township, Frontenac County. In 1925 to 1929 an infestation developed in the Muskoka Lakes section, evidently starting on Morrison Island in Lake Joseph, and spreading to other islands in subsequent years. Surveys of various islands in Lake Joseph in 1928 showed varying proportions of the hemlock trees from 3" in diameter to have been killed by the defoliation. From 10 to 20% of the hemlock had been killed on Hemlock Point, Black Forest Island, Fairy Island, Fisher Island, Bell Island, Rose Island, Loon Island and Elsinore Island; 30% had been killed on Cameron Island; 60% on Governor Island; and 100% on Morrison Island. From 20 to 25% of the hemlock had been killed on Wistowe and Mazingna Islands in the Lake Rosseau. In 1929 the infestation subsided quite generally in the Muskoka Lake territory with the exception of the areas more lightly infested in previous years where some intensification occurred in 1929.

An infestation of the hemlock looper also developed in the area southwest of Brockville in the vicinity of Fernbank in 1926 and 1927. The attack apparently developed very suddenly, with almost outright killing in 1927, affecting the hemlock in pure or nearly pure stands along the St. Lawrence River for a distance of about 12 miles. Similar conditions obtained on the New York side of the St. Lawrence River. The outbreak disappeared suddenly during the 1928 season.

In 1945 and 1946 a small local infestation of the hemlock looper occurred on an island in Budgin Lake in the Sioux Lookout District between Pickle Lake and Lake St. Joseph. Approximately 50% of the balsam fir in the central portion of the Island had been killed as well as a high proportion of the balsam fir understory in the peripheral mixed stand.

A project for the control of the hemlock looper by aerial distribution of calcium arsenate dust was carried out in the Muskoka Lake District in 1928 and 1929. The preliminary dusting experiment was carried out at Lake Joseph July 18 to July 20, 1928. Dust was released from a Keystone Puffer aircraft; applications being made on Leon Island and Laurie Island, each comprising approximately 16 acres, with hemlock an important element of the stand. Very good distribution of the dust was obtained by taking advantage of air drift over the Island. With concentrations of approximately thirty to thirty five pounds of dust per acre, a fair opportunity was provided to determine ability to kill the hemlock looper larvae. It was, however, discovered that only the small larvae were killed, whereas the larger larvae could withstand a heavier deposit than was considered practical to distribute from aircraft.

In 1929 dusting operations were initiated in the latter part of June when the larval population was much younger, and, therefore, more susceptible. The dust was released at an approximate rate of thirty pounds per acre except in areas of extreme damage where an effort was made to deposit forty-five pounds per acre. Very satisfactory distribution of the poison was obtained through skillful operation of the aircraft by the pilot. Dead larvae began to drop to the forest floor within twenty-four hours, and mortality reached its peak about forty eight hours after dusting was completed in any one locality. A mortality of 80% was estimated for the dusting operation carried out over Leon Island, and this operation was handicapped by rainfall within six hours of dusting. In other areas where dust remained undisturbed by rain for a period of twelve to twenty-four hours, mortality among the larval population usually amounted to 90% and, in some cases, approached 100%.

European Larch Sawfly
(Pristiphora erichsonii Htg.)

This pest of larch is presumably of European origin, but its date of introduction to North America is unknown. It was first reported in the Harvard Arboretum, Massachusetts, in 1881, and by 1882-1885 heavy infestations in larch stands were evident throughout eastern Canada. By 1909 and 1910 the insect had become destructive throughout the territory west of Lake Superior, and certain parts of Saskatchewan were infested. During the next two decades, the insect gradually spread westward throughout the entire range of eastern larch in North America, and eventually reached the stands of western larch in the interior of British Columbia.

The female sawflies emerge from the ground in early summer, and deposit eggs in the small twigs on the larch trees, the incisions for egg deposition being placed close together and causing distortion of the twigs upon drying out. The larvae, upon emerging from the eggs, feed upon the foliage and ultimately, at full growth, drop to the ground where they spin cocoons in the moss or debris and overwinter therein.

The history of the European larch sawfly in Ontario cannot be given with any precision because its early depredations in the province ante-dated the existence of any service specifically devoted to the investigation of forest insects. It is certain, however, that many, if not the majority, of the stands of merchantable larch were destroyed before the turn of the century. Although larch stands are widely distributed throughout the province and occur with great frequency, especially in the western region, no estimate of merchantable volumes of this species were included in the 1930 compilation of the forest resources of Ontario. (*) Another expression of the present insignificance of larch in the forest economy of Ontario is the fact that the volumes of this species utilized over the period 1940 to 1943, inclusive, represent approximately one-three hundredths of one percent of the total timber production in the province. Although larch will probably never become of much overall importance because of its occurrence in comparatively small stands, it could in certain districts, assume considerable local importance if permitted to reach maturity. This would seem to be unlikely unless the larch sawfly is kept under control.

By 1919, the insect had again become abundant in the regenerating larch stands west of Fort William, and also in the vicinity of Fort Frances. Reports of infestations in the Huntsville-North Bay

---

* - The Forest Resources of Ontario, 1930. J. F. Sharpe and J. A. Brodie

region have also indicated sporadic attacks in larch stands from 1926 onward, and while little killing of the immature larch has occurred in the infestations during the past decade or two so far as is evident from the reports, the insect pest is well established and occasionally very abundant. In 1945-46 heavy infestations have been evident throughout the Kenora-Sioux Lookout forest districts and there is no evidence of any important biological checks on population increase at this time.

One of the earliest measures taken against the European larch sawfly in Canada was the introduction, starting about 1910, of parasites from abroad. The species Mesoleius aulicus has been distributed throughout many parts of Canada along with the species Bessa harveyi and Tritneptis klugii. In some areas the degree of control exercised by these parasites has been high (80% or more) and this added measure of control along with the destruction of overwintering populations by mice and shrews, and by a fungus disease which is widely distributed, has been sufficient to reduce the sawfly population to non-destructive numbers. Large numbers of Meso leius aulicus have been distributed throughout Ontario, starting in 1910, especially in the southern and eastern larch stands, and in the northern forests more recently. The parasite Bessa harveyi has also been widely distributed from 1939 in the southern and western parts of the province. Evidence obtained in 1945 indicated that the introduced parasites were not very active in the current infestations in the western region and steps have been taken to secure additional parasite material for liberation in these territories in 1947.

European Spruce Sawfly
(Gilpinia hercyniae Htg.)

The European spruce sawfly was introduced to North America at some unknown date, probably several decades ago. During the interval 1930 - 1940, it appeared in destructive outbreaks in eastern Canada and the northeastern States, with most severe consequences in the Gaspe Peninsula , P. Q. In this territory the insect was in violent outbreak for a full decade or longer,and killed very large proportions of the white spruce and the black spruce. The destroyed white spruce amounted to approximately 85% of the total volume over a large territory, but the eastern spruce bark beetle was primarily responsible for the destruction of nearly one-half of the total mortality of white spruce. Approximately one-half to two-thirds of the black spruce volume was killed, and the sawfly was almost exclusively responsible for this destruction.

The insect overwinters in the ground in a tightly woven cocoon from which the adult emerges during early summer. Eggs are deposited in the needles of spruce trees, and the young larvae devour the old foliage, later destroying part of the new foliage in the heavy infestations. At full growth the larvae drop to the ground where they spin cocoons in the moss or in debris. In southern localities, two or more generations may develop in one season, but in northern localities only one generation is developed, and a high proportion of the insects have a prolonged resting period, some of them, in fact, staying in the cocoons for as long as four to seven years.

After the initial discovery of the infestation of this sawfly in the Gaspe Peninsula, it was progressively found further to the west and to the south, and in 1936, a number of samples in the Timiskaming-Haileybury area showed that the insect was established in the northeastern portion of Ontario. By 1938, the insect appeared in southern Ontario, as far to the southwest as London, as well as in the Muskoka territory, but there was apparently no further extension of the known distribution in the Timiskaming area. By 1940, the sawfly was found north of Lake Nipissing, but there had been no serious intensification of the light infestations which had previously been found in some southern parts of the province. Through 1941 to 1944, the insect showed a more or less gradual decline through the infested areas, although some extension was evident by 1944, as far as Sturgeon Falls, Elk Lake, and Kirkland Lake. In 1945 and 1946, the spruce sawfly has been very scarce in northern Ontario, although a few specimens have been recovered occasionally north of Sudbury. So far this species has caused no damage to Ontario forests, but must be kept in constant surveillance because of its proven powers of destruction.

Tremendous numbers of introduced parasites have been released in eastern Canada and the northeastern States, to combat the European spruce sawfly, and several of these have become established and quite effective since the time of their initial liberation in the early 1930's. The major cause of the subsidence of the general outbreaks in eastern North America was, however, a virus disease which fortuitously appeared generally throughout the infestations over a very wide territory in the later 1930's and early 1940's. To what extent this disease has been responsible for the subsidence of the moderate infestations in Ontario, and for the failure of the insect to develop to more destructive populations in areas where it has been recovered for several years, but never in undue numbers, can not be stated. The published reports give little evidence of the occurrence of the disease in Ontario, and definite attempts to establish the disease in southern Ontario have provided no conclusive evidence of its establishment. Fortunately, the causal agent of the disease is being maintained, and it has been proven that the disease can be established by distribution of the causal agent using rather simple methods. Should the European spruce sawfly subsequently show any tendency to multiply in Ontario there is a reasonable expectation of being able to keep it in check.

Pine Sawflies
(Neodiprion spp.)

Several species of native pine sawflies have occasionally appeared in outbreak proportions in forest nurseries and plantations, as well as in forested areas in the Province of Ontario. Considerable work has been done in connection with the investigation of the taxonomic relationships of this hitherto very much confused group of insects, and a certain amount of work has been done in studying infestations in the forest. A considerable number of species are involved, and it is not too certain to what degree the various species have been implicated in some of the past outbreaks. Leconte's sawfly (Neodiprion lecontei Fitch.) has been quite destructive in pine plantations, particularly the red pine plantations in the Kirkwood area about five or six years ago where a large number of trees were killed outright. This insect has also occasionally caused outbreaks in forest conditions. Swaine's sawfly (Neodiprion swainei Midd.), along with some others, appeared in destructive outbreaks in the Lake Kipawa area in western Quebec in 1928 or earlier, and continued for at least six or seven years. In certain plots, over 80% of the trees were killed over a period of years, but it is unlikely that such high mortality was representative of conditions generally, and were more probably related to particular stands under very severe attack.

In 1929, an outbreak also developed in the vicinity of Biscotasing, and some studies were carried out in this infestation in the succeeding years.

While no comprehensive estimate of the damage resulting from these early infestations is at hand, some trees were killed and others were top-killed, and weakening of the trees at that time may be to some extent, responsible for current deterioration of jackpine stands in the same general territory.

In 1946, a fairly intensive infestation of Swaine's sawfly was discovered in the territory around Lady Evelyn Lake in the Timagami division of the North Bay forest district. Areas of particularly heavy infestation occur in Rorke and Whitson Townships, as well as in Tretheway Township at the south of Makobe Lake. Smaller areas of heavy intensity occur along the Lady Evelyn River, and at scattered points along the lake shore in Leo and Dane Townships. Some mortality occurred in jackpine stands in the vicinity of Lady Evelyn Lake. Part of this was due to flooding along the shore line, but this cause is not applicable in the case of jackpine stands at higher elevations which still showed mortality. It is hardly likely that the current infestation is responsible for dead trees discovered in 1946, and it must be assumed that this deterioration has resulted from previous damage, possibly by insects.

Light infestations of Swaine's sawfly have persisted in the vicinity of Kindiogami Lake in the Sault Ste. Marie district through 1945 and 1946, but no serious defoliation has been caused as yet.

Deterioration of Jackpine Stands.

Numerous reports of dying jackpine stands have been received in 1946, and have been investigated in several parts of the province Areas of such deterioration, generally characterized by more or less well-defined sections of dead timber with peripheral rings of trees in a dying condition, have been noted in Ogilvie, Benneweis and Hardiman Townships in the Cogama forest district. In all three areas, there were tremendous populations of Monochamus beetles, evidenced by extreme numbers of pitch masses on the trunks of the trees, and of feeding scars on twigs in the crowns. Comparatively few of the scars made on the trunks by adult beetles had been used for oviposition, except in the case of trees obviously dying. The primary cause of progressive deterioration in Ogilvie and Benneweis Townships is unknown, as the stands are not so overmature that they would not be expected to continue in a healthy state for some decades to come. Possibly previous insect attacks by the jackpine sawfly had weakened the trees beyond

the point of recovery. The unusual multiplication of sawyer beetles in this territory was encouraged by extensive areas of dead balsam and white spruce caused by the spruce budworm, as well as by extensive blow-down. However, the role of the Monochamus beetles in administering the final coup de grace, cannot be stated with certainty in view of the evidence of rather weak attack of these beetles in the trunks of trees still living. In Hardiman Township, the deterioration extended to black spruce, as well as to jackpine, and is probably traceable to very intensive culling of the stand a few years ago for select piling timbers.

Several other areas have been examined, and general findings are shown in synoptic form immediately below.

Leo Township, North Bay District.
Jackpine dead to the extent of 6%, based on two sample strips.
Possible cause; sawfly infestation in previous years.

Dane Township, North Bay District.
Jackpine dead to the extent of 2-12%, based on two sample strips.
Possible cause; as above.

Bannockburn Township, northern part of North Bay District.
Jackpine dead to extent of 55%, based on one sample strip.
Possible cause; as above.

Five miles north of Argon, near Muskeg Lake, Port Arthur District.
Jackpine dead to the extent of 11%, based on one sample strip.
Possible cause; jackpine budworm infestation in late 1930's and early 1940's.

East shore, Big Canon Lake, Kenora District.
Jackpine dead to the extent of 53%, based on one sample strip.
Possible cause; jackpine budworm in late 1930's and early 1940's.

Ewart Township, near Manitoba border, Kenora District.
Jackpine dead to extent of 7%, based on one sample strip.
Possible explanation as above.

Eva Lake, Fort Frances District.
Jackpine dead to extent of 23%, based on one sample strip.
Possible explanation; jackpine budworm as above.

Eltrut Lake, Fort Frances District.
Jackpine dead to extent of 36%, based on tally of 1.5 acres.
Cause of damage; girdling by porcupines (8% kill of black spruce in addition.)

Turtle River, Fort Frances District.
Jackpine dead to extent of 38%, based on tally of one acre.
Possible explanation; jackpine budworm.

These estimates are particular to the localities in which the strips were run, and can not be used for calculation of jackpine mortality over extensive areas. The figures are of use chiefly in illustrating the importance of understanding the role of insects, and other environmental factors in the progressive deterioration of jackpine stands. Much more intensive investigation of this phenomenon is urgently required in the northern Ontario forests.

White Pine Weevil
(*Pissodes strobi* Peck)

The white pine weevil is a native North American pest which has been particularly destructive in white pine plantations as well as in natural regeneration throughout the eastern part of the Continent.

Adult weevils emerge from the ground in the early summer, and cut small excavations in the leader of the tree, depositing eggs therein. The larvae, upon hatching, work under the bark downward in the tree, and effectively girdle the growing tip early in the season. Frequently the trunk is killed for two or three internodal lengths when the attack is particularly vigorous and the internodal lengths are comparatively short. Usually the tree responds to such injury by developing one or more of the lateral branches into substitute leaders, and this frequently results in a tree with several forks, practically useless for the production of valuable lumber.

Much investigational work has been done on this pest in eastern Canada and the northeastern States, particularly in connection with the possibilities of silvicultural prevention of damage through the device of establishing young pine plantations under overstories of deciduous trees, or in plantations by the intermixture of white pine with other rapidly growing conifers, which can be thinned out when the white pine have grown sufficiently to be comparatively free of damage from subsequent weevil attack.

Among more direct measures of control, promising results have been obtained by spraying the tips of trees in plantation with arsenical poisons, and, more recently, with solutions of D.D.T. Another method of control involves clipping off infested tips before emergence of the weevils, and distributing them throughout the infested area in screened boxes which permit the escape of parasitic enemies of the weevil, but prevent the escape of the adult weevils.

A more recent line of investigation in connection with the prevention of weevil damage is concerned with the propagation of resistant stocks of white pine. Some work in this direction was undertaken at the Chalk River Experimental Station a number of years ago, but much more intensive work in connection with the propagation of such stock and the rigorous testing of its immunity to attack, or ability to recover without damage, is necessary before definite hopes of using this technique for large scale establishment of satisfactory plantations can be realized.

European Pine Shoot Moth
(Rhyacionia buoliana Schiff.)

This European pest of pine became established in southern Ontario about forty years ago, and has caused considerable damage in plantations of Scotch and Jack Pine. The injury consists in the destruction of the growing tip and the formation of a marked deformation of the tree, greatly reducing its ultimate value as a source of lumber.

Extensive studies were undertaken over a period of several years in the vicinity of Cedar Bay on the north shore of Lake Erie, and, subsequently, a method of chemical control was worked out which could, it was felt, be applied under plantation conditions.

Defoliators of Deciduous Trees

Maple stands in Ontario have occasionally suffered severe defoliation from a number of defoliating insects including the striped maple-worm (Anisota rubicunda Fab.) and the maple leaf cutter (Paraclemensia acerifoliella Fitch.). Prolonged infestations of the former have persisted in the maple bush of Manitoulin Island where some killing of timber has occurred in recent years, and where, it is reported, a decided decrease in sap-flow has resulted from the progressive weakening of the trees. Field investigations undertaken in 1945 and 1946 indicate a rather marked decline of this persistent infestation through the activies of parasites and other natural control agents including predators and disease.

The maple leaf cutter is native to North America, and has appeared in outbreaks in Quebec and Ontario more or less periodically from 1872. The effect of severe infestations of this insect on maple stands is similar to that of the striped mapleworm, namely, a reduction in vigour of the trees, and a reduced sap-flow. Very intensive studies have been made of the development and ecological relationships of the maple leaf cutter in Ontario, and these have served a very valuable purpose in laying the foundations for similar studies of other important forest pests.

The extensive stands of aspen in northern Ontario have been periodically defoliated by the forest tent caterpillar, (Malacosoma disstria Hbn.). In most instances, outbreaks have disappeared after a few years through the activities of parasites and disease, without resulting in extensive mortality of the host trees.

It is beyond the scope of this brief to review, in detail, other insect pests of Ontario forests, but mention should be made, in passing, of the bronze birch borer, affecting white and yellow birch;

the larch casebearer; the birch sawfly, the birch leaf skeletonizer; the spring and fall cankerworms, which are primarily pests of elm trees; all of which are potential threats to the health and vigour of valuable timber or ornamental species.

OUTLINE OF ESTABLISHMENTS, STAFF AND PROJECTS IN FOREST ENTOMOLOGY.

A. Establishments and Staff, 1946.

1. Establishment and Staff, Ottawa.

The Ottawa staff of the Forest Insect Investigations Unit is comprised of two parts, one of which is concerned with general administration of the Unit throughout Canada, and the other of which is concerned with the work of the Ottawa Laboratory

a. Headquarters staff, Ottawa.

J. J. de Gryse	-	Chief, Forest Insect Investigations Unit
D. E. Gray	-	assistant to the Chief of the Unit
Miss M. McCarney	-	secretary
Miss G. Oswald	-	stenographer
Miss E. M. Arnott	-	"
Miss M. Aquino	-	"
Mrs. H. Finn	-	"

b. Ottawa Laboratory.

i) Administrative.

E. B. Watson	-	officer-in-charge
Miss A. Barnes	-	stenographer

ii) Forest Insect Survey.

J. A. Raizenne
G. Lewis
A. Malcolm
Miss M. L. Tubman
Miss E. C. Hayes
Miss M. L. Watson

iii) Forest Insect Rangers.

H. S. Fleming
R. J. Dubreuil

c. Angus Sub-laboratory.(seasonal)

This field laboratory was established in co-operation with the Department of Lands and Forests in 1939, for the investigation of insects affecting forest nurseries and plantations, as well as those affecting woodlots and shade trees in southern Ontario. During the seasons of 1944, 1945 and 1946, the staff has been engaged in investigations connected with the aerial distribution of D.D.T. sprays over budworm-infested forests.

K. E. Stewart — L. M. de Gryse
E. K. Clarke — J. K. Momose

2. Establishment and Staff under Direction of Sault Ste. Marie Laboratory.

a. Forest Insect Laboratory, Sault Ste. Marie.

This establishment comprises the new laboratory provided by the Department of Lands and Forests, and a field insectary located outside the city at Point aux Pins. The laboratory provides administrative facilities for direction of forest insect work in the organized forest districts of Ontario and the Temiskaming-Lake Nipewa section of Quebec, as well as facilities for technical investigations and laboratory work connected with the forest insect survey. Staff was as follows:

i) Administrative.

M. L. Prebble	-	officer-in-charge
J. M. Cameron	-	second in charge
B. A. Poupore	-	business manager
Pearl Nadeau	-	stenographer
Margaret Virene	-	"
Mary Gallivan	-	"
Fannie Newman	-	
Phyllis Kendall	-	"

ii) Investigative.

K. Graham	-	specialist in insect pathology
J. M. Burk	-	assistant
Ione Wingfelder	-	[illegible]
W. G. Wellington	-	sp[illegible] in meteorology
Olive Johnson	-	[illegible] (seasonal)

iii) Forest Insect Survey.

C. R. Douglas	-	co ordinator (as from September)
G. A. Bradley	-	in charge, Ontario region
Lulu Fremlin	-	assistant
Shirley Fraser	-	"
Stella Oliver (until August)		"
Olive Harvey (seasonal)		"
Mary Fitzgerald (seasonal)		"
Doreen White (seasonal)		"
Patricia Lamothe	-	"
Amy J. McDonald (seasonal)		"
Jean MacIntosh (seasonal)		"
Margaret A. Barnett		"
William MacKay (seasonal)		"

iv) Forest Insect Ranger Service

J. E. MacDonald, chief ranger

(for balance of ranger staff, see end of this sub-section)

v) Maintenance.

W. M. Ferguson - engineer
C. E. Gooderham - engineer
Edward Ross - caretaker
John Wilton - caretaker

b. Chalk River Field Station, at Dominion Forest Service Experimental Station.

This station, comprising a combined residence and laboratory, and an insectary, established for forest insect research in the eastern forest region of Ontario, was not staffed in 1946 owing to the lack of trained personnel.

c. Laniel Field Station, Kipewa Lake, P. Q.

This station, comprising a forest insect laboratory and a genetics laboratory, with auxiliary buildings such as insectary, bunkhouse, boathouse, workshop, etc., established for forest insect investigational needs in the Temiskaming-North Bay region, was fully staffed in 1946.

i) Forest Insect Bionomics.

D. A. Ross - entomologist
J. W. Hutton - assistant (seasonal)
H. Pesner - assistant (seasonal)

ii) Forest Insect Genetics.

S. G. Smith - geneticist
J. Marcovitch - assistant (seasonal)
C. Comberg - assistant (seasonal)
W. Y. Watson - assistant (seasonal)

iii) Maintenance.

A. Berube - cook (seasonal)
A. Denis - caretaker

d. Algonquin Park Field Station, South Tea Lake, Algonquin Park comprising two cabins made available for seasonal use by the Department of Lands and Forests, was not staffed in 1946 owing to the lack of trained personnel.

e. Ranger Lake Road Field Station, Curtis Township, [illegible] Sault Ste. Marie, comprising two cabins made available for seasonal use in 1946 by Mr. S. T. Lewis of Searchmont, was staffed as follows:

J. L. Hitchon - entomologist
H. E. Burke - assistant (seasonal)
Robert Burns - assistant (seasonal)
Richard Hamer (part-time) - specialist in mathematics and physics.

f. Algoma Forest Ecological Field Party, temporarily established during the season for about one month in each of the following localities; Ranger Lake Road, Mississagi River, Montreal River. The staff was provided largely by the Department of Lands and Forests, who also bore practically the entire expense of maintaining the party in the field.

K. B. Turner - forester, in charge (Provincial)
R. Schafer - forester, assistant (Dominion)
J. H. Shand -)
J. T. Basham -)
W. W. Wahl -) assistants (Provincial)
A. E. Kowal -)
J. A. Minnes -)
A. G. Lancaster -)
D. Sturgeon - compiler (Dominion)
J. J. Kennedy - cook (Provincial)

g. Black Sturgeon Lake Field Station, north of Port Arthur, comprising one residence and log buildings made available for the season by the Great Lakes Pulp & Paper Company, was staffed as follows:

N. R. Brown - entomologist, in charge
Arthur Blades - assistant (seasonal)
Gordon Cameron - [illegible]

J. J. Fettes - entomologist (part time at Eaglehead Lake)
G. T. Harvey - assistant (seasonal) " " "
W. E. Beckel - assistant (seasonal) " " "
C.D.F. Miller - assistant (seasonal) " " "
J. C. Higgins - assistant (seasonal) " " "

J. R. Blais - entomologist (part-time at Big Canon Lake)
A. H. Rose - assistant (seasonal)

R. M. Belyea - entomologist
J. B. Lewis - assistant (part time)

B. M. McGugan - entomologist
W. R. Henson - seasonal assistant to W. G. Wellington
J. V. Clarke (vice S. McRae) - cook (seasonal)

h. Forest Insect Rangers, district personnel.

i) Pembroke, Parry Sound, North Bay -
W. J. Miller and D. G. MacGillivray

ii) Sudbury, Chapleau, Gogama -
H. R. Foster and F. A. Bricault

iii) Sault Ste. Marie -
A. G. McDonald (assistant to J. E. MacDonald)
and A. L. Rose

iv) Cochrane - Kapuskasing -
H. G. McPhee and G. A. King

v) Geraldton -
Perry Teatro

vi) Port Arthur -
Angus Harnden

vii) Sioux Lookout -
S. W. Lukinuk and G. R. Carter

viii) Kenora - Fort Frances -
J. M. Bussineau and L. S. MacLeod

B. Summary of Investigative Projects with Officers-in-Charge.

Most of the investigative projects in operation in 1946 have been concentrated on various aspects of the spruce budworm problem, because of the extreme seriousness of this problem in the Province of Ontario as well as in adjacent provinces and states, and because much more intimate knowledge than has been available hitherto is required for the determination of population trends and of the effectiveness of natural control factors, as well as direct control procedures; and for the recommendation of remedial measures. Such lack of precise knowledge cannot be overcome at once, certain highly technical problems still await the acquisition of intensively trained staff. It is therefore realized that many of the investigations must continue for several years at least.

Another investigative project in 1946 has been concerned with the control of wood borers in logs left in the bush during the summer season.

Investigations in Insect Pathology - Dr. Kenneth Graham.

Insects are attacked by many kinds of disease-producing micro-organisms, including bacteria, fungi, viruses and protozoa, relatively specific to the insect class. Numerous records exist on the spectacular subsidence of infestations as a result of diseases destroying the insects. Several striking examples occurring in recent years will serve to illustrate the potentialities of entomogenous microorganisms.

The first of these is the case of the European spruce sawfly which by 1938 occurred in heavy infestation over some 12,000 square miles of forest in eastern Canada. By 1943, five years after a virus disease was observed to kill the sawfly larvae, it had so reduced the insect population that important defoliation of trees had ceased.

The second case is that of the black-headed budworm, which occurred in outbreak abundance in large regions of the hemlock forests of the British Columbia and Washington coast between 1940 and 1945. The feeding by the insects caused an intense reddening of the foliage which presented an alarming picture to all who observed it. In the Salmon River area of Vancouver Island the insects killed enormous volumes of merchantable timber over some 15,000 acres. In those areas where serious timber mortality did not occur, the favorable outcome was attributable largely to the early destruction of the insects by a virus disease.

A third example is that of the hemlock looper which in Oregon was brought under control by a virus, now active in certain infestations of the looper outbreak in British Columbia.

The foregoing examples are sufficient to illustrate the fact that agents of disease have the properties which enable them, under favorable conditions, to bring about effective control of insect outbreaks. The fact that they do not always exert their effect in time to avert damage indicates an opportunity to assist the natural course of events by artificial dissemination of the effective agents of disease before they normally would be adequately distributed or before they would attain their highest virulence.

Attempts in the past to disseminate agents of disease were generally ineffective. This should in no way discredit the premise that scientific knowledge can be applied to advance the natural course of events.

The advantages inherent in the use of entomogenous microorganisms over chemicals, lie in the fact that they are self-propagating once established and they do not present any hazard to life other than the insects against which they are used.

The development of the science of insect pathology toward the practical utilization of diseases for control of insects will proceed in several stages.

i) The first stage consists of a survey of microorganisms associated with each species of insect concerned. This investigation is prerequisite to the selection of the most effective agents of disease, and provides a record of the localities from which diseases of any particular type may be obtained. Most of the work during 1946 has consisted of a survey begun along this line, particular attention having been given to spruce budworm and hemlock looper. The progress of this survey has been limited to a considerable extent by serious lack of staff trained in bacteriological and related techniques and by lack of special facilities needed for such work. On the other hand, the progress and extent of the work have been favored by the assistance of our own field staff in Ontario, and of co-operative field staff in other provinces and in the State of New York, in submitting forest insect material suspected of harboring pathogenic microorganisms. Specialists in the United States have contributed to the work by the identification of some of the microorganisms cultured from diseased insects.

As a result of the survey of diseases during 1946, some forty or more distinct microorganisms representing the bacteria and fungi have been isolated and cultured from spruce budworm. In addition, a virus disease has been identified from one collection of that species of insect. In hemlock looper a dozen or more bacteria, fungi and viruses have been observed.

ii) A second phase of the work will consist of detailed anatomical and cytological studies of the insects, as a background to diagnosis of virus diseases and as a background for the recognition of variations in the virus reflected in changed symptomatology.

iii) A third phase of investigation will consist of the purification and serological identification of viruses. The importance of maintaining purity of virus strains cannot be overemphasized, since the admixture of two related pathogenic strains of certain viruses, at least, is known to result in mutual interference and no disease. The procedures in purification and identification of viruses require special skill and equipment.

iv) The assessment of pathogenicity of the microorganisms is a fourth phase of the work essentially distinct from the survey itself. The testing of bacteria, fungi and viruses must be carried out first under controlled laboratory conditions, then in small-scale field tests. At present the agents of disease in spruce budworm which justify most attention are a fungus which was isolated from specimens from the Nipigon region, and a virus which occurs in the Adirondacks of New York state. The agents of disease most clearly implicated in killing hemlock looper are a virus and a fungus disease. The role of the many kinds of bacteria often associated with the virus diseases is not yet clear, but it would be contrary to bacteriological principles to dismiss them as being secondary.

v) A fifth [illegible] of laboratory investigations to develop the highest virulence in the selected microorganisms. This is one of the most important considerations of the entire problem, and failure in the past to recognize the inconstancy of virulence under all conditions is undoubtedly one of the main reasons for past failures in attempts to utilize diseases to control insects.

vi) A sixth phase of the work will involve a careful epidemiological study to determine the actual performance of diseases already active in field populations. At the present time two infestations which may provide valuable information include the spruce budworm in the Adirondacks and the hemlock looper in British Columbia.

vii) The phase of work which will be the culmination of all other investigations on disease will be the study of methods of dispersal, leading to the actual utilization of microorganisms to combat forest insects on a practical scale.

[illegible] Spruce Budworm
[illegible] (balsam fir and [illegible] jackpine) - Dr. S. G. Smith

This project was initiated four years ago to clarify the [illegible] different host trees. These populations [illegible] in that infestations on spruce and [illegible] contiguous jackpine stands, [illegible] worse. Moreover, the

general behaviour of the populations was different; population trends of the two forms, even when infestations occurred simultaneously in practically the same territory, were not at all similar, the jackpine budworm populations tending to decline when concurrently the spruce budworm populations were being maintained or even increased. Differences in seasonal development, in coloration, in size, etc. were noted in studies of the two forms, but no clear morphological differences were then apparent to justify a decision as to their inherent distinctness. The cytogenetic investigations were designed to determine the genetic relationships of the two forms, and most particularly, to determine whether natural crossing or hybridization was likely to occur, and with what likelihood of success.

The investigations have included mate-choice tests, studies of fertility, percentage of hatch and cytology of the two forms and the hybrid between them, and analysis of barriers to interbreeding in the natural populations.

i) Evidence of the degree of relationship between the balsam and jackpine forms were obtained by observing the mating preferences shown by the moths when one or both sexes of one form were caged with both sexes of the other form. Results obtained over a two year period show approximately three times as many mate selections among two sexes of the same host form as compared with the selection of mates involving different host forms. This would tend to prove that the moths themselves recognize the existence of innate differences between them, and such sexual isolation, if operative under natural conditions, would tend to reduce the chances of hybrid matings occurring.

However, vigorous hybrid larvae resulted from cross-bred moths in cage experiments. These hybrid larvae were more easily reared on balsam and larch foliage than on jackpine foliage, and in their rate of development resembled the balsam form more closely than the jackpine form. On the other hand, the hybrid moths were almost indistinguishable from the jackpine form, especially in wing coloration and pattern. The colour pattern of the jackpine form is therefore dominant as contrasted with the color pattern of the balsam form.

ii) In studies of fecundity the mean number of eggs laid by the balsam form in captivity was about 106, by the jackpine form about 160, and by the hybrids about 96. There is a high degree of variability in such statistics, but the evidence at hand suggests that the hybrid populations are very similar in fecundity to the balsam form.

Similarly, the number of eggs contained per egg cluster has been determined under experimental condition. The females of the

jackpine form deposit, on the average, about 38 eggs per cluster on jackpine foliage, but this average is reduced to about 33 if oviposition is forced to occur on the shorter balsam fir needles. Egg clusters laid by balsam form females contain 17 eggs on the average. First generation hybrid females averaged between 17 or 18 eggs per cluster regardless of the origin of the male involved in the mating. Therefore, in respect to the size of the egg mass, the balsam form is dominant.

Studies of the percentage of hatch under experimental conditions have shown that approximately 89% of eggs laid by females of the balsam form hatch (i.e. 11% sterility), approximately 86% of the eggs laid by jackpine females hatch, but only about 64% of eggs laid by hybrid females. In contrast, however, with the latter percentage of hatch, either balsam or jackpine type females when mated with a hybrid male produced eggs which hatched to the extent of 88-89%.

The increased sterility associated with hybrid females is traceable to differences of the chromosomes, not in number but in the arrangement of their parts, between balsam and jackpine forms. Such differences in the arrangements of parts should result in segmental deficiencies and duplications following reassortment of chromosomes such as occurs at egg cell production in the hybrid female. Such sterility would not be expected in crosses involving females of either the balsam or jackpine form, and males of the hybrid type, because competition between sperms contributed by the hybrid male would lead to the elimination of abnormal types, and therefore would lead to fertilization without involving incompatibility in chromosome types.

iii) In the analysis of barriers tending to separate the balsam and jackpine forms from cross breeding in nature, two factors have been noted; namely, differences in seasonal development and differences in the daily rhythm of mating activity, that would seem to be rather effective barriers. In general the balsam form is approximately two weeks earlier in seasonal development than the jackpine form, and as the adults are comparatively short lived this would tend to reduce the likelihood of simultaneous occurrences of moths of the two forms. Secondly, analysis of observed mating times of balsam type moths and of jackpine type moths shows that the balsam forms tend to mate earlier in the day than jackpine forms , the mean mating period for the balsam forms occurring at about 8 p.m , while that of the jackpine form is about 10:30 p.m.

To summarize, the following differences are now evident between the balsam and jackpine forms of the budworm; (a) morphological size and color differences, (b) differences in host preference, (c) differences in time of seasonal development,(d) differences in number of eggs per cluster, relative fecundity, and in arrangement of parts of their chromosomes, (e) differences in daily mating rhythm. Some of these differences clearly act as barriers to cross

mating of the two types in nature, and such isolation barriers could scarcely have been evolved without the prior occurrence of the chromosome changes which initiated the partial sterility barrier effective against continued inbreeding.

Investigations of the Reactions of the Spruce Budworm to Physical Factors of the Environment.

- W. G. Wellington -

Effects of Variable Microclimatic Conditions upon the Behaviour and Activity of the Spruce Budworm.

- W. G. Wellington and W. R. Henson -

These two closely related projects, the first consisting of observations and careful experiments in the laboratory and under controlled conditions in the field, and the second consisting of observations under carefully described conditions in natural infestations, are designed to establish the relationships of various types of behaviour and activity, and the physical factors in the natural environment. The expression of such relationships is found first, in the distribution of the insects on the tree; second, in their movements in the stand and [illegible] from hibernation, which is suspected of being a factor in at least short distance migration, and the late season[illegible] past by hunger in heavily defoliated stands); and third, in the flight reactions of the moths, which are undoubtedly involved in extensive migrations of the adult forms (heavy flights of moths have been observed in Port Arthur, Sudbury, Windsor and Chicoutimi) An intimate knowledge of these relationships is necessary to an understanding of migration and spread of infestations, and is, moreover, basic to practically all work in sampling the insect populations, undertaken for the purposes of determining population levels, trends, the importance of natural control factors, etc.

The first serious study of the relationship of spruce budworm behaviour and physical factors of the environment was initiated in 1946. Certain of the conclusions are noted briefly here:

i) Larvae of all developmental stages normally react positively to light over a wide range of temperature, but at high temperature they react negatively. This ensures their concentration in the upper parts of the tree or at the outer ends of branches, except in very hot weather, when they will seek concealment.

ii) Starved larvae of the later developmental stages react negatively to directed light (point source).

iii) There is no evidence of any temperature preference, and no [illegible] temperature reactions, except the negative reaction to light at high temperatu[illegible]

iv) The reactions to evaporation rate are clear cut, and related to the previous experience of the larvae; i.e., ones previously kept in a moist environment seek a higher evaporation rate than those previously kept in a dry environment.

v) The movement and the rate of travel are also influenced by temperature and evaporation rate, being greater at higher temperatures and in dry air. A practical illustration of the value of such knowledge is the defining of environmental conditions within which satisfactory sampling work can be done, and beyond which movements of the larvae are likely to cause the sample results to be unreliable.

vi) Behaviour in the field has been found to conform to the above-noted conclusions.

vii) Heavy larval populations by their own feeding activities (defoliation of the trees) gradually modify the physical environment so that greater extremes in the physical factors are experienced. There would thus be less stability in the populations on severely defoliated trees, and the trees themselves are more liable to be affected by extremes in weather (e.g., greater proportions of new shoots killed by frost).

Much more intensive investigations in the meteorological factors [illegible] planned for subsequent seasons, an immediate aim being the study of [illegible] governing dispersal and migration of newly emerged larvae in the spring, and of moths in mid-summer.

Investigation of Sampling Techniques for Population Studies of the Spruce Budworm in Ontario.

- J. J. Fettes -

The establishment of a sound system of sampling will be recognized as one of the first essentials of any program involving periodic evaluation of population densities. The establishment of adequate systems in forest entomological work is always difficult, and this difficulty is enhanced when there is a number of host tree species [illegible], differing in growth characteristics, degrees of attractiveness, and degrees of reaction to the influence of the insect attacking them, as in the spruce budworm problem. A critical analysis of the distribution of foliage types in balsam fir trees, and the distribution of [illegible] individuals in these types and in the trees, was initiated in 1946. The analysis of accumulated data is not yet complete, but it is anticipated that considerable improvement over previous sampling methods will result from these special investigations.

Investigation of the Development of the Spruce Budworm.

- B. M. McGugan - Black Sturgeon Lake.

The following additions to the knowledge of the Departmental history of the spruce budworm in Ontario and Western Quebec, have been contributed by Messrs. McGugan, D. A. Ross, and others engaged in special project work.

i) At the time of emergence from the over-wintering quarters, all or nearly all, of the young larvae excavate needle mines in the needles of the old foliage, usually of the preceding year's growth. Approximately nine to ten days are spent in the first needle mines during which most of the inner tissues are devoured, and the needle tends to dry up, particularly in the case of balsam fir. The growing larvae then vacate these first mined needles, and may either excavate new mines in other needles or begin to enter the newly opening shoots. In the case of balsam fir, the buds usually open early enough to permit entry of young budworm larvae after only one or two needles have been mined by each larva. In the case of white spruce, the buds also open early and the larvae enter them about the same time as they enter the balsam fir shoots, but the old spruce needles are less succulent and are mined less thoroughly by the young larvae, and consequently as many as six or seven adjacent spruce needles may be partially mined by one larva before it is able to find an opening bud for entry. In the case of black spruce, the new shoots open quite late, and the larvae must spend a correspondingly long period in the needle-mining phase of their development.

ii) The young larvae which have emerged from hibernation in the second larval stage tend, in large part, to complete this stage of development in the needle mines, and also part of the third stage. However, a few second stage larvae are found in the new shoots, and the latter are commonly occupied by larvae of the third and fourth developmental stages. The subsequent developmental stages usually feed on the new foliage of the expanding shoot, and frequently, by necessity, on old foliage in the case of severe defoliation.

iii) The small larvae of the second stage, on issuing from hibernation, commonly lower themselves from the branches on spun threads, and are frequently dispersed by wind. This is an important factor in the dispersal of the insects throughout the tree crowns, and from tree to tree, but whether extensive dispersal of the young larvae from year to year commonly results, requires additional intensive study.

iv) Larvae of the successive stages are not readily distinguished with certainty, and this difficulty in the identifications of the larval stages occasions some uncertainty in the interpretation of natural control data, in that certain parasitic species make their attack on the budworm in different larval stages. The accurate assessment of parasite activity therefore requires an accurate knowledge of the larval stages being handled. The search for reliable diagnostic features in the larval stages will be continued.

v) The duration of their developmental stages is approximately as follows: eight to nine days for the pupae, ten to eleven days for adult life on the average, and seven to eight days for the egg stage in late July and August.

iv) The newly hatched larvae are very active, wandering about and dropping down on spun threads. With a very few exceptions, all the observations indicate that the larvae establish over-wintering shelters on the twigs without having fed. Within these shelters, the young larvae transform to the second larval stage within a day or two, or somewhat longer, and remain quiescent until the following spring.

Investigations of the Rate of Yolk Consumption by the Over-wintering Larvae of the Spruce Budworm.

- Dr. S. G. Smith -

Special investigations were undertaken to determine the nutritional circumstances involved in the hibernation without feeding of the newly hatched larvae. It has been discovered that the newly hatched larva contains in its alimentary tract a store of yolk derived from the egg. Examination of microscopic sections made from progressively older larvae has shown that the yolk is totally converted into fat tissue within four to six weeks of hatching, and this fat tissue serves as a source of food during the quiescent period which lasts until the following spring. These young hibernating larvae are, in several respects, very unique in that they are, in effect, still in the embryonic condition because hibernating larvae examined as late as March were still devoid of respiratory and circulatory systems as well as certain excretory organs. However, considerable development of the alimentary tract had occurred subsequent to hatching. These young hibernating larvae are therefore functionally quite different from the phase which takes up active feeding at the time of needle mining or entry into the new shoots, and it is quite possible that the reactions of these non-feeding over-wintering larvae to external factors would be quite different from those exhibited by active feeding stages. This, at least, would be expected in their

reaction to disease microorganisms normally ingested with the food, and will require very intensive study in connection with any programme for the dissemination of disease microorganisms in the field.

Investigations in the Life History, Development, and Natural Control of the Spruce Budworm.

- D. A. Ross - Lake Kipawa.

Investigations of Parasites in the Natural Control of the Spruce Budworm.

- N. R. Brown - Black Sturgeon Lake.

Weather conditions prevailing in April and May exert a strong influence on the spruce budworm populations. Over-wintering larvae respond to unusually warm weather early in the spring, and frequently issue from hibernation some weeks in advance of bud bursting. In such cases they must become established in needle mines for a long period in order to survive. There is, undoubtedly, a heavy mortality of young larvae shortly after leaving their winter quarters, but no satisfactory method of measuring the degree of mortality among the very minute larvae during this period has been worked out.

Even after the young larvae are established in needle mines they are not immune to the effect of severe frosts. Illustrations of the importance of late frosts on mortality of the spruce budworm in the needle mining and bud inhabiting stages are given below:

1944 Laniel-North Bay Region (freezing temperatures occurring May 18th - 22nd. Mortality assessment, May 22nd)
5 localities - 6% - 15%

1945 Laniel-North Bay Region (freezing temperatures on 20 days during April. Mortality measured at end of April)
Gagnon's Creek P.Q. - 62%
5 other localities - 14% - 26%

1945 Laniel-North Bay Region (additional heavy frosts in late May to early June. Measurement of budworm mortality among larvae established in the buds.)
Laniel - 37%

1946 Laniel-North Bay Region (repeated heavy frosts in May. Mortality estimated among larvae in needle mines in late May.)
Gagnon's Creek P.Q. - 7%

1946 Laniel-North Bay Region (occasional frosts in early June. Mortality measured in bud inhabiting larvae in early June.)
Gagnon's Creek P.Q. - 6%

Statistics on proportions of the well developed larvae and pupae destroyed by parasites are summarized below:

Laniel-North Bay Region (Infestation declining in successive years.)

Year	Percentage of larvae killed by parasites.	Percentage of pupae killed by parasites
1944-Little Jocko River	34 %	
1944-3 other localities	24 %	
1944-Laniel		6 %
1945-Laniel	32 %	16 %
1946-Gagnon's Creek	34 %	46 %
1946-2 other localities	16% - 29%	

Curtis Township, Sault Ste. Marie (Infestation declining)

Year	Percentage of larvae killed by parasites.	Percentage of pupae killed by parasites
1945	55 %	32 %

Black Sturgeon Lake (Infestation maintained or rising)

Year	Percentage of larvae killed by parasites.	Percentage of pupae killed by parasites
1944	10 %	9 %
1945	5 %	6 %
1946- 4 localities	15% - 33%	7% - 22%

In summary, parasites destroy variable proportions of the budworms which have survived unfavorable weather conditions in early spring. In the early stages of an active rising infestation usually the proportion of the well-grown larvae destroyed by parasites does not exceed 10%; and of pupae, 5 - 10%. With prolongation of the outbreak, the parasite populations rise, the host population tends to drop through partial exhaustion of the food supply, and increasing proportions of the larvae and pupae are killed by parasites. In some instances, one-third to one-half of the well grown larvae, and similar proportions of the pupae, are destroyed by parasites. Such comparatively high control by parasites seems, in Ontario, to be confined to the later stages of an outbreak, when damage to the timber has already been done, and therefore while contributing to the rapidity of decline of outbreaks, the native parasites, so far as known, have not prevented the rapid rise and extension of such outbreaks.

Various parasitic species, not native to Ontario, have been released in this province through the Belleville Parasite Laboratory, in an effort to establish more effective agents for the control of the spruce budworm. One of these, Phytodietus fumiferanae, obtained from British Columbia, has been recovered in the Black Sturgeon Lake area from budworm larvae in the vicinity of the point of release. It remains to be seen how thoroughly this and other imported species disperse throughout the infested area, and how effective they will be in the control of the spruce budworm.

Investigations of the Sex Ratio in the Spruce Budworm.
- Dr. S. G. Smith -

The sex ratio of a species (proportion of females to males) is an important factor in connection with the potential rate of population increase. The ratio may fluctuate from place to place, and at different times in the outbreak cycle, as a response to environmental factors, if one sex is less resistant than the other to unfavorable environmental conditions. Dr. S. G. Smith has discovered a cytological technique whereby sex can be determined in the newly hatched larvae, as well as older ones, and this makes possible the determination of the sex ratio at all developmental stages of the spruce budworm. This provides a valuable tool for the accurate determination of differential mortality of the two sexes at different times during development and at different periods in the outbreak cycle.

Preliminary results based on cytological examinations suggest that more female eggs than male eggs are deposited by the budworm moths, (the ratio cannot be stated with accuracy as yet on the basis of available data); and that at time of hatching, the two sexes are approximately equal in numbers, which suggests somewhat higher mortality of the females during the incubation period. The sex of the pupae and of the moths is easily determined by microscopic examination, and a number of sex ratios determined by investigative staff in infestation centres follow:

YEAR	PLACE	CONDITION OF LOCAL INFESTATION	SEX RATIO (FEMALES TO MALES)
1944	Laniel, PQ.	declining	1.03 (moths)
1945	Algonquin Park	declining	.72 (moths)
1944	Black Sturgeon Lake	rising	1.22 (moths)
1945	Black Sturgeon Lake	temporary and slight decline	1.04 (moths)
1946	Black Sturgeon Lake	rising	1.20 (pupae)
			1.18 (moths)

These figures give little evidence of any striking differential mortality among the two sexes, with the possible exception of the 1945 Algonquin Park population, which was definitely on the wane. It must be admitted, however, that the significance of a sex ratio in the pupa or adult stage cannot be fully appreciated without an exact knowledge of the sex ratio in the same population at egg laying and at hatch. The full significance of sex ratios in field populations must depend upon a knowledge of the proportions at all important stages, whence the possible influence of environmental factors upon differential mortality may be judged. The only conclusion that can be drawn at present is that the flourishing populations in the Black Sturgeon Lake territory comprised a fairly high proportion of females, and that in certain areas where the populations virtually disappeared there was no catastrophic disappearance of the reproducing element of the population.

With more research in this phase of the investigations, it may be possible to forecast with some accuracy the direction of population trends.

Effect of Balsam Fir Staminate Flowers on the Rate of Development, Survival and Fecundity of the Spruce Budworm, with Analysis of the Relation between Tree Condition and Severity of Insect Attack.

- J. R. Blais -

In the investigations relating to the effect of various foods (different host trees and types of foliage) on spruce budworm development, preliminary results obtained in 1946 were as follows (1) There was complete mortality in the younger larval stages of all spruce budworms reared exclusively on old foliage (1945 growth) of balsam fir, white spruce and black spruce; (2) larvae developed more rapidly on certain types of acceptable food than on others, in the following order of decreasing rate of development: i. balsam fir staminate flowers and associated foliage ii. new foliage of white spruce, iii. new foliage of balsam fir, iv. new foliage of black spruce; (3) fecundity of the ensuing adult females was greater on certain food schedules than on others, in the following approximate order of decreasing rate of fecundity i. white spruce new foliage, ii. balsam fir staminate flowers and associated foliage, iii. balsam fir foliage without flowers, iv. black spruce new foliage, v. balsam fir foliage from area of old heavy infestation. These results give support to the idea that rate of development, survival and fecundity of the spruce budworm are linked with the food supply.

Field observations carried out by American entomologists in eastern Ontario and western Quebec in 1945 led to the tentative conclusions (1) that rate of development, intensity of population, and severity of damage were greater on flower bearing trees than on nonflowering trees in the same stand, (2) that flowering trees were favored by the moths at egg laying, (3) that the prevalence of flowering trees was related to the growing conditions, being more numerous at younger ages on the poorer sites, and (4), that removal of flowering trees, regardless of size, should reduce susceptibility of the stand to budworm damage. This concept is very important in relation to the management of spruce-balsam fir stands, or other stands containing appreciable quantities of the budworm host trees. Much critical investigational work is required, however, in various parts of Ontario, before definite recommendations for the reduction of budworm hazard through management practices can be made on the basis of established fact. In particular, it is important to know the lower limits of balsam spruce content, or stand per acre, or of age on sites of various degrees of suitability for growth of these species, that constitute a condition of hazard during present or future outbreak cycles, in order that management recommendations may be made sufficiently definite, without being so sweeping as to be impossible of attainment. In this connection it is important to recognize that the careful management of very small blocks may not accomplish the hoped for hazard reduction, if large surrounding

areas are left in an uncontrolled state, capable of developing huge bud worm populations which may migrate and destroy contiguous balsam spruce stands which in themselves do not favor a population increase of the insects.

Studies are in progress in the Wabigoon River territory to determine whether the physiological condition of the balsam fir stands is clearly and consistently related to the intensity of attack and damage. No conclusive results are available as yet. In passing, it is worthy of note that an answer to this problem is not readily determinable in the area about Black Sturgeon Lake, where most of the stands of balsam are of the "staminate" or flower-bearing type (a condition possibly not unrelated to the severity of the infestation in that territory).

Effect of Forest Composition on Susceptibility to Damage by Insect Outbreaks with Special Reference to the Spruce Budworm.

- K. B. Turner -

Investigations to determine the influence of stand composition, and of contiguity to heavy outbreak centres, upon damage resulting from a sustained spruce budworm outbreak were started in the Algoma Region in 1946, as a joint project of the Department of Lands and Forests and the Forest Insect Laboratory. Surveys were carried out in the following territories: (1) the Mississagi River Valley, reaching from the southern portion of township 3E northwards to the vicinity of Pesha and Hinckler Lakes (an area of severe infestation first evident about the mid 1930's). (2) the Ranger Lake Road, ranging from Whitson Township northeastward towards Ranger Lake (an area of variable infestation intensity, lying athwart the border zone of the recent outbreak). (3) the Montreal River area (ACR), extending from the township of Home eastward (an area of variable infestation intensity, lying athwart the border zone of the recent outbreak). In each area cruise lines were run at successive intervals and detailed tallies of all tree species, by one inch diameter classes starting at the one-inch class, and class by class each tree as living or dead, were carried out. Careful notes were also taken on forest composition, site characteristics, and developmental history of the stand. Certain portions of the survey lines were marked for re examination in subsequent years, and small plots established for periodic re examination of the regeneration. Much additional analysis will be necessary to bring out all the facts contained in the 1946 survey data, and moreover the same type of investigations should be conducted in other regions to broaden the basis of the sampling of budworm affected forests of Ontario. In the meantime, however, it is possible to present in summary form some of the more obvious results of the work of this past season. Synoptic data are included in the following tables.

In the Mississagi territory damage has been exceptionally heavy. At Mileage 56, which represents the approximate southern border line of the severe infestation, about 80 to 90% of the balsam fir has been killed out including practically all of the merchantable sizes and large proportions of the smaller diameter classes as well. White spruce has also been killed to the extent of approximately 24 to 30% in this territory, and an exceptional mortality of 80% of white spruce, including practically all trees of sawlog size, occurred in a mixed forest type. Relatively smaller proportions of the black spruce have been killed in this section of the territory. The tables for the successively higher mileage points on the Mississagi Road representing conditions more to the centre of this old outbreak area disclose, on the whole, some increase in the mortality of balsam fir which generally is in excess of 90%, and in several areas reaches 100%. Similarly, increased mortality of white spruce was found in association with the more complete destruction of balsam fir; for example, 94 to 100% of the white spruce volume had been destroyed in cover types C-2, M-3, and H-3 at Mileage 68 - 69, and similar proportions will be found in tables relating to the Hinckley Lake and Seabrook Lake localities. Even black spruce has been rather seriously affected when intermixed with balsam fir and white spruce and hardwoods, frequently to the extent of 50% or more, and in a few exceptional cases to the extent of over 90%. Such exceptionally high mortality of black spruce, however, usually occurred only when this species was greatly overridden by balsam fir and white spruce in the stand, suggesting that the black spruce was disastrously affected in these cases by larval populations overflowing from the balsam fir and white spruce. Pure black spruce stands, relatively infrequent in the Mississagi territory, were not so seriously affected.

In the Ranger Lake Road territory studies were carried out on either side of the approximate line of demarcation between persistent heavy infestations, and infestations which lasted only for a year or two. This line of demarcation would be approximately at Mileage 11. While the tabulated data on mortality of balsam fir and white spruce did not show an abrupt change in the vicinity of Mileage 11, there is, however, a gradual progression in the degree of mortality as one approaches the higher mileage points; that is, as one gets further into the area of persistent heavy infestation. Even outside of the approximate demarcation line from 15 to 43% of the balsam fir was destroyed in the different cover types; the mortality of white spruce was more variable, ranging from 0 to 19% in stands where white spruce was relatively infrequent, and to somewhat higher proportions where white spruce was represented only by the occasional trees. It is noteworthy that equally high mortality of balsam fir and white spruce occurred in mature, virgin, mixed forests as in mature, virgin, coniferous forests, and only slightly less in the mature, virgin, hardwood forests. Contrary to the findings of investigators who had studied earlier outbreaks in eastern Canada where the hardwood crown canopy was considered to represent a marked degree of protection for the intermixed or understory balsam fir and white spruce.

Generally, the black spruce in the Ranger Lake District suffered relatively light damage. A few exceptional instances were noted, however, where as high as 23 to 30% of the black spruce had been killed when growing in virgin, mature, coniferous stands, and second growth coniferous stands in mixture with overriding proportions of white spruce and balsam fir. Practically no damage had occurred to black spruce growing in pure black spruce swamps.

In the Montreal River area a succession of lines was run in the forest starting in Home Township close to the Algoma Central Railway, and extending approximately fifteen miles to the east. The exact location of the border line between persistent and more temporary infestations in this area cannot be stated, but there was, in general, a tendency for the westerly portion to be more lightly and less persistently attacked during the recent outbreak.

A reflection of the gradation in intensity of attack as one progresses eastward is provided by the increasing mortality of balsam fir in the mature, virgin, coniferous cover type rising from 53% in Home Township to 95% in Townships 24-25 Range XVI, fifteen miles farther east. In the mixed and hardwood forest, however, this trend is not apparent. Black spruce has suffered rather seriously in certain parts of the Montreal River territory to the extent of 30% or more in several of the groups summarized in tabular form, and in one exceptional area (Township 25 Range XVI) to the extent of 72% in the virgin, coniferous forest.

More searching analysis of the relationships between stand composition, density of softwood volume per acre, etc., and mortality will be undertaken later. It is also confidently expected that similar work can be extended to other portions of Ontario. The conclusions derived from this line of investigation will be of tremendous value in the formulation of any recommendations for handling forested areas under threat of spruce budworm attack.

EXPLANATION OF SYMBOLS USED IN FOLLOWING TABLES

Bf	Balsam fir
Sw	White spruce
Sb	Black spruce
C-1	Mature, virgin, coniferous forest
C-2	Moderately culled, mature, coniferous forest
C-3	Severely culled, mature, coniferous forest
C-4	Second growth, coniferous forest
C-5	Young growth, coniferous forest
M-1	Mature, virgin, mixed forest
M-2	Moderately culled, mature, mixed forest
M-3	Severely culled, mature, mixed forest
M-4	Second growth, mixed forest
M-5	Young growth, mixed forest
H-1	Mature, virgin hardwood forest
H-2	Moderately culled, mature hardwood forest
H-3	Severely culled, mature hardwood forest
H-4	Second growth, hardwood forest
H-5	Young growth, hardwood forest

MISSISSAGI ROAD

Mileage 56 (2 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc: Budworm Hosts			% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	.75	2640	800	631	Bf	644	72	80	83	100	100	86
					Sw	171	54	30	29	-	0	24
					Sb	392	36	7	7	0	-	9
C-4	.25	2819	520	1578	Bf	326	65	83	-	-	-	77
					Sw	235	41	40	33	-	-	32
					Sb	160	33	27	0	-	-	21
M-1	.1	2884	1065	378	Bf	1072	42	100	100	100	-	99
					Sw	205	33	75	0	-	-	31
					Sb	164	66	0	0	-	-	4
M-4	.55	2821	721	665	Bf	690	83	84	100	-	-	90
					Sw	459	70	62	86	100	100	80
					Sb	286	35	33	17	0	-	18
H-1	.1	2449	1614	7	Bf	605	83	100	100	-	-	86
					Sw	173	44	17	0	-	-	13
					Sb	50	0	0	-	-	-	0

MISSISSAGI ROAD

Mileage 58-59 (4 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc		Budworm Hosts	%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality By Volume
C-1	0.9	3356	86	529	Bf	741	66	96	100	100	-	97
					Sw	111	47	13	50	100	-	62
					Sb	1889	6	11	25	78	100	34
C-4	0.093	2402	346	1119	Bf	401	6	33	33	-	-	35
					Sw	528	0	40	75	100	-	76
					Sb	8	0	-	-	-	-	0
M-1	1.15	2984	1760	268	Bf	621	19	48	61	100	-	54
					Sw	333	54	63	54	25	100	54
					Sb	2	-	0	-	-	-	0
H-1	0.85	5176	2381	105	Bf	48	15	58	87	100	-	74
					Sw	199	50	37	64	100	-	61
					Sb	-	-	-	-	-	-	-

MISSISSAGI ROAD

Black Creek, Township 3E (2 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc	Softwoods Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortali By Volume
C-1	.175	16474	477	13978	Bf	1070	16	72	100	100	-	95
					Sw	518	33	0	29	0	100	46
					Sb	432	29	0	0	0	-	1
C-4	.05	1264	111	417	Bf	121	100	100	-	-	-	100
					Sw	518	0	100	75	-	-	78
					Sb	98	-	50	-	-	-	75
M-1	1.25	3018	1325	910	Bf	389	14	62	71	100	-	68
					Sw	353	26	20	48	100	-	34
					Sb	41	17	0	0	0	-	0
H-1	.425	5506	4349	131	Bf	810	24	90	93	-	-	88
					Sw	216	28	71	86	50	-	76
					Sb	-	-	-	-	-	-	-

MISSISSAGI ROAD
Mile 60-63, Township 3E (4 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc: Budworm Hosts		Age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	Age Mortali By Volume
C-1	.35	2700	179	1599		Bf 276	53	62	80	100	-	71
						Sw 256	88	75	0	0	-	8
						Sb 389	21	20	11	0	-	14
M-1	2	3371	1497	548		Bf 878	21	87	96	100	100	92
						Sw 292	22	74	64	17	71	61
						Sb 56	14	14	13	0	-	11
M-4	.3	1504	588	190		Bf 574	13	67	67	-	-	61
						Sw 148	0	17	67	0		34
						Sb 4	-	0	-	-	-	0
H-1	.95	3213	2345	229		Bf 463	10	54	85	100	100	67
						Sw 176	8	0	40	-	50	33
						Sb 0	0	-	-	-	-	0

MISSISSAGI ROAD

South of Missisagi River, Township 4 E (3 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortali By Volume
C-1	.35	2472	1037	806		Bf	534	10	43	100	100	100	74
						Sw	96	0	0	0	100	-	41
						Sb	--	-	-	-	-	-	--
M-1	.775	7556	2340	4096		Bf	822	22	80	92	100	100	94
						Sw	295	16	0	-	0	75	60
						Sb	--	-	-	-	-	-	--
M-2	.275	1757	462	644		Bf	309	28	100	100	100	-	91
						Sw	342	0	-	60	100	100	78
						Sb	--	-	-	-	-	-	--
M-3	.625	2843	950	444		Bf	598	52	87	96	100	-	91
						Sw	247	50	25	94	100	-	92
						Sb	4	-	0	-	-	-	0
H-1	.975	5356	3889	908		Bf	465	36	53	86	-	100	68
						Sw	94	12	20	33	0	-	23
						Sb	--	-	-	-	-	-	--

MISSISSAGI ROAD

Mileage 66, Little Trout Creek (2 Lines)

Cover Type Designation	Acres Tallied	Volumes per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc:	Softwoods Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortali By Volume
M-1	.75	2250	705	175	Bf	745	15	73	96	100	100	87
					Sw	436	9	21	40	40	33	38
					Sb	189	50	26	39	-	-	33
M-2	.2	897	318	164	Bf	238	6	67	75	-	-	64
					Sw	150	40	0	33	-	-	35
					Sb	27	-	-	0	-	-	0
M-4	.15	1409	472	37	Bf	504	14	33	89	-	-	78
					Sw	386	33	40	83	-	-	71
					Sb	10	0	0	-	-	-	0
H-1	.7	2495	1339	54	Bf	982	6	65	93	100	-	86
					Sw	121	14	75	0	100	-	85
					Sb	-	-	-	-	-	-	-
H-4	.05	1974	1503	42	Bf	419	0	100	100	-	-	80
					Sw	9	0	-	-	-	-	0
					Sb		-	-	-	-	-	-
H-5	.05	895	344		Bf	551	0	-	100	100	-	93
					Sw	-	-	-	-	-	-	
					Sb	-	-	-	-	-	-	-

MISSISSAGI ROAD

Mileage 68-69 (3 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.		Budworm Hosts	Percentage of Stems Killed by Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	Percentage Mortality By Volume
C-2	.05	5056	4	-	Bf	2486	90	100	100	-	100	100
					Sw	2002	0	-	-	100	100	100
					Sb	564	-	-	-	-	0	0
C-3	.225	729	322	-	Bf	165	10	100	100	-	-	93
					Sw	214	0	0	0	-	100	76
					Sb	27	0	-	0	-	-	0
M-2	.575	2956	1337	300	Bf	895	59	96	100	100	-	96
					Sw	407	10	40	0	67	100	76
					Sb	16	0	0	0	-	-	0
M-3	1.45	2671	624	553	Bf	1286	74	94	97	100	100	97
					Sw	149	12	14	100	100	100	94
					Sb	58	23	18	83	100	-	63
H-2	.2	2595	1670	94	Bf	648	45	91	100	100	-	95
					Sw	16	0	-	-	-	-	0
					Sb	168	0	0	0	0	-	0
H-3	.1	2096	1140	-	Bf	743	78	91	100	-	-	97
					Sw	212	-	-	-	100	-	100
					Sb	-	-	-	-	-	-	-

MISSISSAGI ROAD

Mileage 70 - 71 (4 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-4	.2	1486	252	1147	Bf	8	35	-	-	-	-	49
					Sw	35	8	0	-	-	-	0
					Sb	44	33	100	-	-	-	98
M-2	1.35	1107	112	553	Bf	356	85	99	100	100	-	98
					Sw	37	91	100	100	-	-	100
					Sb	49	80	75	100	-	100	98
M-3	1.2	2837	360	988	Bf	1330	66	98	98	100	100	98
					Sw	218	44	83	92	100	100	97
					Sb	51	53	100	67	-	0	40
H-1	.625	2284	1584	285	Bf	390	67	100	100	100	-	100
					Sw	25	0	-	100	-	-	99
					Sb	-	-	-	-	-	-	-
H-2	.625	3773	1296	1160	Bf	1082	42	100	100	100	100	100
					Sw	235	24	33	56	50	0	41
					Sb	0	0	-	-	-	-	0
H-3	.25	11363	7276	2980	Bf	1076	83	100	100	100	-	100
					Sw	30	27	50	-	-	-	56
					Sb				-	-	-	-

MISSISSAGI ROAD

Southwest of Peshu Lake, Township 4D (2 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% age of Stems Killed by Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortal By Volume
C-1	1.5	2552	159	688	Bf	1263	68	99	100	100	100	99
					Sw	242	31	100	86	100	100	95
					Sb	201	52	30	50	100	-	56
M-1	.5	3633	353	2102	Bf	1041	76	100	100	100	-	100
					Sw	100	8	100	100	100	-	97
					Sb	39	50	0	0	-	-	0
H-1	.1	5479	1829	3064	Bf	274	0	33	0	-	-	8
					Sw	312	0	-	-	-	100	99
					Sb	-	-	-	-	-	-	-

MISSISSAGI ROAD

Southwest of Hinckler Lake, Township 5D (3 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	1	3520	206	1799	Bf	875	85	99	98	100	100	98
					Sw	388	20	27	50	100	100	79
					Sb	252	16	9	0	0	-	5
C-3	.4	3052	449	466	Bf	1468	84	100	100	100	-	96
					Sw	480	50	86	44	80	100	73
					Sb	188	29	0	0	-	100	52
M-1	.35	4042	725	2329	Bf	506	86	97	100	100	-	96
					Sw	256	21	37	75	100	-	66
					Sb	227	18	5	0	-	-	10
M-2	.35	1482	309	250	Bf	915	75	100	100	100	100	100
					Sw	202		100	100	100	100	100
					Sb	6	-	100	-	-	-	100
M-4	.2	1689	383	772	Bf	265	53	100	100	-	-	97
					Sw	499	0	20	67	-	-	48
					Sb	69	0	0	0	-	-	0
H-1	.45	3026	1804	587	Bf	393	91	93	100	100	100	97
					Sw	242	14	67	100	100	100	96
					Sb	-	-	-	-	-	-	-

MISSISSAGI ROAD

South of Seabrook Lake, Township 4E (3 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc	Budworm Hosts		Percentage of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	Percentage Mortality By Volume
C-1	2.475	5816	805	3962	Bf	744	64	97	100	100	-	97
					Sw	208	22	33	50	60	100	77
					Sb	95	9	17	20	0	50	26
M-1	.35	3409	854	911	Bf	1054	71	100	100	100	-	99
					Sw	401	0	75	-	100	100	99
					Sb	187	17	33	100	100	-	91

MISSISSAGI ROAD

Southeast of Seabrook Lake, Township 5E (3 lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	% Hardwood	Softwoods Misc. Budworm Hosts			% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortali By Volume
C-1	.05	805	120	-	Bf	685	100	-	-	100	-	100
					Sw	-	-	-	-	-	-	-
					Sb	-	-	-	-	-	-	-
C-4	1	1707	337	382	Bf	684	85	97	100	100	100	99
					Sw	245	62	29	83	100	100	95
					Sb	60	27	100	100	100	-	99
M-1	1.525	2916	1015	1019	Bf	737	83	91	100	100	100	98
					Sw	144	59	75	88	50	100	83
					Sb	-	-	-	-	-	-	-
H-1	.425	3608	3125	2	Bf	402	100	92	100	100	100	97
					Sw	70	25	66	0	-	-	46
					Sb	9	-	100	-	-	-	100

RANGER LAKE ROAD

Mileage 8, Whitman Township (3 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total:	Hardwood	Softwoods	Misc: Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality By volume
M-1	.625	3928	1770	1348	Bf	423	1	10	42	100	-	27
					Sw	379	0	29	0	20	-	17
					Sb	8	0	0	-	-	-	0
H-1	1.775	2910	2165	267	Bf	206	3	10	27	100	100	29
					Sw	269	7	0	0	0	10	8
					Sb	3	0	0	-	-	-	0

RANGER LAKE ROAD

Mileage 9, Whitman Township (3 lines)

Cover type designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc: Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age of Mortal: By volume
M-1	.5	3210	1842	995	Bf	317	4	14	42	67	-	36
					Sw	45	0	0	-	0	-	0
					Sb	11	-	-	0	-	-	0
H-1	1.80	2951	2430	259	Bf	178	4	15	29	0	-	18
					Sw	71	0	40	0	0	0	4
					Sb	13	0	-	-	0	-	0

RANGER LAKE ROAD

Mileage 10-10½, Whitman Township (5 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	.2	2811	1407	616		Bf	678	11	4	14	100	-	22
						Sw	106	27	0	-	0	-	1
						Sb	4	0	-	-	-	-	0
C-4	.3	2043	34	1038		Bf	241	7	9	100	-	-	17
						Sw	26	0	33	-	-	-	45
						Sb	703	9	29	20	-	-	23
M-1	1.55	3007	2078	387		Bf	380	8	2	36	67	-	25
						Sw	140	5	10	25	0	25	19
						Sb	21	0	-	0	0	-	0
H-1	2.95	2915	2195	426		Bf	206	13	8	41	30	-	22
						Sw	88	7	6	0	50	0	9
						Sb	--	-	-	-	-	-	--

RANGER LAKE ROAD.

Mileage 11, Whitman Township (5 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc: Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	1.075	2829	257	1194	Bf	592	20	19	33	50	-	28
					Sw	145	18	11	0	0	0	2
					Sb	640	9	16	22	28	33	26
C-4	1.6	2455	780	79	Bf	1303	39	13	9	37	-	15
					Sw	114	14	3	0	-	0	1
					Sb	180	17	13	33	17	50	29
M-1	.825	2403	1176	140	Bf	932	28	4	7	40	-	13
					Sw	144	3	0	0	0	-	0
					Sb	10	-	-	0	-	-	0
H-1	.55	2497	1445	425	Bf	500	13	14	42	50	-	43
					Sw	125	0	-	-	0	50	38
					Sb	1	0	-	-	-	-	0

RANGER LAKE ROAD

Mileage 11½, Curtis Township (6 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	2.	2112	181	540	Bf	789	27	17	27	100	0	23
					Sw	60	23	0	0	0	0	0
					Sb	543	0	0	4	26	0	9
C-4	1.2	1395	169	122	Bf	915	9	2	17	10	0	8
					Sw	68	0	0	0	0	-	0
					Sb	121	0	0	0	0	100	42
M-1	1.05	2119	257	747	Bf	766	14	14	27	45	-	25
					Sw	203	5	0	0	20	0	6
					Sb	146	0	0	0	33	0	9
M-4	1.25	866	273	17	Bf	457	19	11	13	0	-	12
					Sw	67	0	0	0	0	-	0
					Sb	52	0	0	0	0	-	0
M-5	.1	454	381	-	Bf	40	0	-	-	-	-	0
					Sw	26	0	-	-	-	-	0
					Sb	8	0	-	-	-	-	0

RANGER LAKE ROAD

Mileage 11½ - 12, Curtis Township (6 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total: Hardwood	Softwoods	Misc: Budworm Hosts			% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortali By Volume
C-1	3.4	1712	123	200	Bf	883	21	15	28	33	0	22
					Sw	110	0	5	0	0	-	1
					Sb	394	2	3	5	9	0	5
C-4	1.4	863	87	41	Bf	579	9	7	14	66	-	16
					Sw	22	0	0	0	-	-	0
					Sb	135	0	0	0	0	-	0
M-1	.3	2172	389	16	Bf	1414	38	21	10	100	0	26
					Sw	258	0	0	-	20	0	18
					Sb	94	-	-	0	0	0	0
H-4	.15	2822	1207	983	Bf	576	20	0	0	-	-	3
					Sw	47	5	-	-	-	-	1
					Sb	9	0	-	-	-	-	0

RANGER LAKE ROAD

Mileage 12½. Curtis Township (5 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu. Ft.) Total	Hardwood	Softwoods Misc.	Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	1.5	2600	297	76	Bf	1750	22	28	34	47	100	36
					Sw	213	0	10	8	33	0	14
					Sb	263	0	13	0	25	-	7
C-4	.85	2322	559	-	Bf	1566	49	16	21	11	50	19
					Sw	155	100	11	13	-	50	29
					Sb	41	18	0	-	0	-	0
M-1	2.275	3367	1420	83	Bf	1534	22	21	29	35	40	28
					Sw	307	0	0	19	40	8	18
					Sb	23	-	67	0	0	-	14
M-4	.1	1711	300	-	Bf	1162	18	0	33	100	-	23
					Sw	20	-	0	-	-	-	0
					Sb	228	-	-	-	0	-	0

RANGER LAKE ROAD

Mileage 13-13½. Curtis Township (5 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc.	Softwoods Budworm Hosts		% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	1.225	1804	261		360	Bf	932	20	33	37	50	0	37
						Sw	196	0	0	0	0	0	0
						Sb	55	0	0	0	-	-	0
M-1	2.675	3176	1243		960	Bf	831	16	26	41	69	40	48
						Sw	130	0	0	30	33	20	31
						Sb	12	0	0	0	-	-	0
H-1	.7	3831	2834		310	Bf	397	17	23	41	75	100	55
						Sw	290	0	0	0	0	33	24
						Sb	-	-	-	-	-	-	-

RANGER LAKE ROAD

Mileage 14 - 15, Curtis Township (3 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc: Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality By Volume
C-1	.65	1618	102	457	Bf	670	6	15	36	57	0	37
					Sw	344	14	0	0	17	50	23
					Sb	44	0	-	50	0	-	27
M-3	1.325	3673	900	841	Bf	1604	8	20	40	76	80	52
					Sw	288	0	17	50	0	11	16
					Sb	39	0	0	0	0	-	0
M-4	.575	486	146	11	Bf	271	16	13	28	100	-	38
					Sw	17	0	0	0	-	-	0
					Sb	41	0	0	0	-	-	0
H-1	.275	88	77	---	Bf	11	11	-	-	-	-	3
					Sw	-	-	-	-	-	-	-
					Sb	-	-	-	-	-	-	-

RANGER LAKE ROAD

Mileage $18\frac{1}{2}$ - $20\frac{1}{2}$, Township 22, Range X, and Township 3H (5 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc: Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortalit By Volume
C-1	1.2	2632	145	880	Bf	763	14	40	66	50	-	54
					Sw	497	7	0	0	17	0	2
					Sb	347	5	13	6	17	-	11
C-5	.05	297	--	95	Bf	--	-	-	-	-	-	--
					Sw	--	-	-	-	-	-	--
					Sb	203	0	0	-	-	-	0
M-1	2.075	2008	888	96	Bf	557	17	45	54	100	-	52
					Sw	339	5	3	10	29	20	18
					Sb	128	4	11	0	33	0	11
H-1	1.425	2826	2537	37	Bf	204	13	16	33	100	-	30
					Sw	48	12	0	0	0	0	0
					Sb	--	0	-	-	-	-	0
H-4	.1	533	165	7	Bf	324	0	17	50	-	-	35
					Sw	37	0	0	-	-	-	0
					Sb	--	-	-	-	-	-	--

RANGER LAKE ROAD

Mileage 21½-23. Township 3H (5 Lines)

Cover Type Designation	Acres Tallied	Volumes Per Acre (Cu.Ft.) Total	Hardwood	Softwoods Misc	Softwoods Budworm Hosts		%age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	%age Mortality By Volume
C-1	.725	25158	1419	12724	Bf	5709	43	87	95	100	100	92
					Sw	1882	22	30	41	36	81	58
					Sb	3425	7	14	22	33	46	30
M-1	4.2	609	111	142	Bf	217	43	77	95	100	50	90
					Sw	117	11	23	35	57	40	42
					Sb	21	9	33	25	0	100	44

MONTREAL RIVER

Home Township, 2 miles east of A. C. R. (4 lines)

Cover type Designation	Acres Tallied	Volumes Per Acre (Cu. Ft.) Total:	Hardwood	Softwoods	Misc: Budworm Hosts			Percentage of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	Percentage Mortality By Volume
C-1	.25	8618	1152	3521		Bf	1367	12	19	50	80	100	53
						Sw	562	0	33	33	0	0	4
						Sb	16	0	0	-	-	-	0
M-1	.55	8484	4680	1085		Bf	1652	6	12	38	57	67	45
						Sw	1065	2	11	0	14	20	14
						Sb	2	0	0	-	-	-	0
H-1	1.1	9110	7806	511		Bf	529	8	16	58	82	50	63
						Sw	264	100	100	100	100	50	61
						Sb	--	-	-	-	-	-	--

MONTREAL RIVER

Township 26, Range XV, 6 miles east of A.C.R. (6 lines)

Cover Type Designation	Acres Tallied	Volume Per Acre (Cu. Ft.) Total	Merchantable	Softwoods	Misc. Budworm Hosts		Percentage of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13	Percentage Mortality By Volume
C-1	2.3	4303	[illegible]	1307	Bf	603	8	44	58	87	100	58
					Sw	[illegible]	5	22	0	11	33	23
					Sb	781	9	4	21	40	30	30
M-1	1,975	4652	1984	1319	Bf	826	7	33	57	84	100	62
					Sw	497	4	0	33	43	56	55
					Sb	26	0	0	0	100	-	28
H-1	1,825	4156	3616	169	Bf	214	5	17	32	70	0	42
					Sw	151	17	0	29	-	25	23
					Sb	-	-	-	-	-	-	-

MONTREAL RIVER

Township 26, Range XV, 7-8 miles east of A. C. R. (4 lines)

Cover type Designation	Acres Tallied	Volume Per Acre (Cu.Ft.) Total	Hardwood	Softwoods	Misc: Budworm Hosts			% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortalit By Volume
C-1	2.35	4936	1436	2170	Bf	786		19	50	79	90	100	75
					Sw	351		7	13	21	10	27	32
					Sb	191		19	24	5	60	50	32
M-1	1.225	4058	2198	889	Bf	516		10	20	52	73	-	53
					Sw	455		7	10	0	33	43	30
					Sb	--		-	-	-	-	-	--
H-1	.775	4069	3168	173	Bf	324		36	40	50	50	100	66
					Sw	356		30	20	0	50	25	41
					Sb	47		-	-	-	0	-	0

MONTREAL RIVER

Township 25 Range XVI, 11 miles east of A. C. R. (4 lines)

Cover type Designation	Acres Tallied	Volume Per Acre (Cu.Ft.) Total: Hardwood	Softwoods	Misc: Budworm Hosts			% age of Stems Killed By Diameter Class 1 - 3	4 - 6	7 - 9	10 - 12	13+	% age Mortality By Volume
C-1	2.75	4069	852	1083	Bf	1500	60	80	86	94	100	89
					Sw	628	20	56	57	80	57	63
					Sb	205	26	59	70	70	75	72
M-1	.875	3724	1489	844	Bf	639	20	49	54	70	67	61
					Sw	252	0	20	25	20	46	47
					Sb	--	-	-	-	-	-	--
H-1	.375	4271	2784	623	Bf	441	0	0	43	75	100	57
					Sw	424	0	50	-	-	100	96
					Sb	--	-	-	-	-	-	--

MONTREAL RIVER

Township 24-25, Range XVI, 15 miles east of A. C. R. (3 lines)

Cover type Designation	Acres Tallied	Volume Per Acre (Cu. Ft.) Total	Hardwood	Softwoods	Miscellaneous Budworm Hosts		% Age of Stems Killed By Diameter Classes 1 - 3	4 - 6	7 - 9	10 - 12	13+	% Age Mortality By Volume
C-1	1.5	3933	519	1271	Bf	1423	70	82	96	100	100	95
					Sw	243	28	12	33	67	57	55
					Sb	477	17	15	48	56	17	32
M-1	.775	3765	1980	48	Bf	1423	57	75	84	100	100	89
					Sw	220	0	0	33	67	50	48
					Sb	94	0	0	0	0	-	0
H-1	.075	5147	3549	--	Bf	1417	15	17	50	67	-	49
					Sw	181	-	-	-	0	-	0
					Sb	--	-	-	-	-	-	--

Investigation of Insect Populations in Dying Balsam Fir Trees with Special Reference to Deterioration and Salvability.

- R. M. Belyea -

This project was undertaken to clarify the role of various factors, especially some of the bark beetles, bark weevils and wood borers, in the dying of balsam fir following defoliation by the spruce budworm. It is particularly desirable that reliable symptoms of approaching death be known, as well as the time limits of salvability, in order that salvage of dead and dying timber be encouraged to the fullest possible extent. Investigations were started on a systematic basis in 1946, with major attention being devoted to the search for symptoms of declining vigor in defoliated trees. Rates of deterioration in killed timber, and the probable limits of salvability, will be investigated more fully in following seasons.

Investigations of the Bionomics of Sawyer Beetles and other Wood Borers and their Control.

- J. L. Hitchon -

In years characterized by unseasonably early spring break up, many logs are liable to be stranded in the bush for a full twelve months or more, and heavily attacked by sawyer beetles and other borers during the summer season. Such damage may seriously depreciate the value of lumber ultimately sawn from the logs, and there have been many enquiries regarding methods of protecting stranded logs during the summer months. Storage in lakes or streams would prevent practically all such damage, but usually is not possible under the conditions that lead to logs being left in the woods during the summer. Covering the skidways with brush has been used in some instances, but requires a great deal of careful effort for deep and thorough coverage. Spraying the skidways with mixtures of diesel oil, lubricating oil and crude creosote has also been carried out with some success, but the application requires careful timing to coincide with the appearance of the young borer larvae under the bark. Some operators have attempted to prevent attack by distribution of salt over the skidways (a measure whose basis is unknown to, and whose effectiveness is seriously questioned by, the writer).

The insecticide, DDT, is capable of killing large proportions of insects coming in contact with it, its residues are persistent under favorable conditions, and therefore it would seem to be a promising material for use in protection of log skidways. Investigations toward this end in the United States were quite promising, and therefore trials under Ontario conditions were started in 1945. Oil solutions and water emulsions of DDT, in concentrations from 1.25% to 10% of DDT, were applied in June and early July to skidways on commercial operations in six widely separated portions of Ontario, but results of the applications were very inconclusive, due, it was felt, to the possibility of inadequate coverage in some instances, unfavorable timing of applications in others, and excessive weathering due to heavy rainfall after application.

In 1946, the investigations were concentrated in Curtis Township in the Sault Ste. Marie district, where special skidways of spruce, balsam fir and pine logs were set up in each of two locations by personnel of the laboratory staff under special cutting privileges granted by the District Forester. Oil solutions and water emulsions of DDT in concentrations of 5% and 10%, and a mixture of diesel oil, used lubricating oil and crude creosote, were applied to the skidways at carefully determined times. Heavy attack developed in the untreated skidways, and in those not sprayed until late in the summer. The water emulsion sprays of DDT, (both 5% and 10%), applied before beetle flight began, reduced borer attack to light proportions; and the oil sprays of DDT, almost eliminated attack, especially the 10% oil spray of DDT. A considerable degree of control was also afforded by the crude creosote mixture, but this treatment was decidedly less satisfactory than the DDT oil sprays.

It therefore appears to be established that logs left in the bush during the summer can be adequately protected by the application of protective sprays before beetle flights commence in June. The oil solutions of DDT, which seem most promising, present certain difficulties in that stocks of kerosene, as a carrier, and of velsicol or some other solvent, must be hauled in to the skidway locations, and this is sometimes difficult. The water emulsions do not present this difficulty, as water from pools or streams can be used as the carrier for the spray. The required quantities of DDT and of solvent and emulsifier are so comparatively small that no difficulties in transportation are presented. The investigations will be extended on a commercial scale in 1947 for large scale testing and cost estimation if stranded skidways are available. Simultaneously, attempts will be made to determine the minimum application and concentration of sprays for adequate protection.

Cytological Survey of the Coleoptera (beetles).

- Dr. S. G. Smith -

This is a co-operative project involving specialists in cytology and in systematic entomology, to assist in the classification of insect forms belonging to very difficult groups where morphological characters indicative of distinctness between the closely related forms are not readily found. The contributions of cytology to systematic entomology, and thus directly to economic entomology, are already clearly exemplified in the increased knowledge of two major forest insects, the European spruce sawfly and the spruce budworm, made possible by cytological investigations.

Application of Concentrated Sprays by Aircraft for the Control of Forest Insects.

- K. E. Stewart -

The application of sprays for the control of insect pests over large tracts of forest, had until recent years seemed impossible. Prior to 1944, the United States had conducted studies on the aerial application of sprays, using highly concentrated mixtures prepared from regular insecticides. Because of their lack of fluidity, great difficulty was experienced in devising suitable apparatus for their dissemination and while the volume had been reduced, the weight was still excessive. With the appearance of the modern, highly toxic insecticides such as D.D.T., 666, 1068, etc. that may be prepared as sprays, with a consistency not much greater than water, interest in the application of sprays by aircraft was given a great impetus. At the suggestion of the Department of Lands and Forests, Ontario, the Division of Entomology undertook to investigate thoroughly the application of these materials from aircraft for the control of forest insects. The spruce budworm was chosen as the principal test insect because of its present economic importance to the forest industry.

During the course of the investigation, the following features had to be considered:

i) Types of aircraft likely to be suitable from the standpoint of spray delivery, costs and safety.

ii) Development of disseminating apparatus to deliver the required type of spray.

iii) Formulation of efficient aerial spray mixtures.

iv) Devising technique to determine the most effective spray clouds and their physical characteristics, such as size and number of droplets and their distribution, evaporation, drift, etc.

v) Influence of meteorological conditions on the action and performance of spray clouds.

vi) Appraisal of the degree of insect control.

vii) Effect of the sprays on other forms of animal and plant life.

viii) Navigation problems relating to uniform coverage when treating extensive areas.

ix) Development of efficient spray mixing and loading technique.

x) Costs.

During 1944, the United States Bureau of Entomology and Plant Quarantine supplied 100 pounds of D.D.T. and the Department of Lands and Forests 300 pounds later in the season. Tests were made with aircraft and spraying equipment supplied by the United States Department of Agriculture and the Department of Lands and Forests. Difficulties with spraying equipment prevented actual tests being made with D.D.T. until the moth stage of the spruce budworm. The sprays were effective in killing the moths, but not the pupae or eggs. Sprays were also applied at the rate of five gallons and five pounds per acre, to a plantation heavily infested with the red-headed pine sawfly, Neodiprion lecontei, with successful results. In conjunction with the Ontario Fisheries Research Laboratory, two separate lake and river areas were sprayed at the rate of six to eight pounds of D.D.T. per acre to determine the effect on fish and aquatic invertebrates.

With the co-operation of the Quebec Government detailed investigations were conducted during 1945 in Northern Quebec as a combined project with the Department of Agriculture and the United States Bureau of Entomology. A Waco aircraft fitted in pontoons and equipped with rotary distributing units developed by the United States Department of Agriculture, was used throughout the year. These investigations yielded most valuable information. Important improvements were made in the spray formulae, through the selection of more efficient solvents, carriers and emulsifiers. The required D.D.T. concentration and the necessary amounts of deposited D.D.T. were determined within a narrow limit. It was found that dosages as low as one gallon of spray and one pound of D.D.T. per acre were sufficient to control the spruce budworm, if applied between the time the budworm leaves the buds and enters the prepupal stage. Methods for appraising the degree of budworm control as the result of spraying operations were greatly improved. It had been presumed that the D.D.T. deposited on the trees would remain effective against insect life for a very long period. However, it was shown to retain its deadliness for only five to eight days. With the assistance of the Chemical Warfare Division, Canadian Department of National Defence, a technique was developed to simplify the counting and measuring of droplet sizes. Valuable information was gained on the influence of meteorological conditions on spray clouds, including rate of descent, drift and evaporation. This has an important bearing in determining the most efficient droplet sizes, as upon this depends the ability of spreading a small volume of spray over a large area.

During 1945, the Ontario Department of Lands and Forests conducted a large scale aerial spraying operation in an effort to control the spruce budworm over an area of 100 square miles in the Lake Nipigon region. An important contribution was made as the result of this operation; namely, the development of a "pin-point" method of charting spray flights, using aerial photographs which assured reasonably accurate spray coverage of an area to be treated. The spray was released at a presumed rate of one pound of D.D.T. per acre.

Field personnel of the Sault Ste. Marie Laboratory, under the direction of N. R. Brown, undertook, i) determination of spray distribution at fixed points along a line traversing part of the sprayed area at Little Sturge lake, ii) estimation of the percentage of the budworm population destroyed by the spray, and iii) estimation of the reduction of defoliation resulting from the operation. Examination of sprayed forest was also carried out in 1946, a year after the spray program. It was concluded that about two-thirds of the budworm larvae were killed by the spraying operations; that defoliation was reduced from about 96% of the new foliage in the unsprayed forest, to 30% in one part of the sprayed forest, and to 63% to 70% in other parts of the sprayed forest; but there was sufficient survival in the sprayed forest, possibly augmented by migrations of the moths from the surrounding unsprayed forest, to serve as the source of large numbers of eggs, which though less abundant in the sprayed forest than in the surrounding unsprayed forest, were nevertheless considered sufficient for a heavy infestation in 1946. Examination on August 1, 1946, of the section of the sprayed forest along the 1945 base line showed that 100% of the 1946 foliage had been destroyed, in other words, the infestation following the spray operation was essentially the same as in unsprayed areas. This conclusion was confirmed in aerial reconnaissance of the Lake Nipigon infestation area a few days later, as no difference in intensity of defoliation could be detected in the sprayed and unsprayed forest in the vicinity of Little Sturge Lake. It would therefore appear that the principal effect of the 1945 spray operation in this area was to defer severe defoliation for one season.

In 1946, the Department of Lands and Forests decided to conduct a large scale spraying operation in an effort to gain additional essential data. K. E. Stewart was seconded to the Department of Lands and Forests to plan and direct this operation. It was planned to treat thirty-five square miles, in the Eaglehead Lake Area, some fifty miles north of Fort William. A canso Model A. Aircraft (1) was employed to deliver the sprays. Because of the density of the forest stand, it was decided to spray at the rate of two gallons per acre. This required a delivery of one hundred and sixteen gallons per minute and a new type of equipment was recommended to replace the simple gravity-fed apparatus used on the Cansos in 1945 which delivered only forty gallons per minute. The new equipment gave excellent performance and produced an exceptionally uniform spray pattern. Ten test plots were sprayed to obtain additional information on dosages and effectiveness

(1) Late in 1946, exploratory tests were carried out in conjunction with the Provincial Air Service at Timagami, in testing spray distribution from a Norseman aircraft, the pontoons of which were equipped with a special orifice for spray delivery from one of the compartments. Promising results were obtained.

of various types of sprays. The remainder of the area was treated as a large scale spraying project. A field camp was established on Eaglehead Lake for the purpose of marking out the plots, and appraising the degree of control obtained. The aircraft was operated from the Fort William airport and the average ferrying distance to project area was fifty-one miles. The plane delivered an average of five hundred and fifty gallons on each trip, flying at 140 miles per hour at an altitude of 150 feet and with an effective swath of two hundred feet, treated 56.56 acres per minute. Ninety-six loads were sprayed over an area of approximately forty square miles. During the course of the project some sixty-thousand gallons of spray and thirty-five tons of D.D.T. were used. In determining the effectiveness of the operation some five hundred sampling stations at intervals of one hundred and thirty-two feet were established across the area. An enormous amount of data relating to the percent control obtained, D.D.T. deposit, spray spectrum, drift, spray action under various meteorological conditions, effect on wild life, time and costs etc., are in the process of being analyzed and it will be some weeks before this will be in a presentable form. Based on observations in the field at the conclusion of the operation, it seemed evident that the budworm population had been almost entirely eliminated in the sprayed area. Defoliation was also very light in 1946, in contrast with heavy defoliation in the surrounding unsprayed forest. The ultimate effects of the operation on the budworm infestation in the sprayed area, and on the sprayed forest, can only be determined in 1947 and subsequent years.

C. Forest Insect Survey in Ontario.

The Forest Insect Survey in Ontario is conducted from two centres; namely, the Ottawa Laboratory, which is responsible for survey work in the southern portions of Ontario, and the Sault Ste. Marie Laboratory, which is responsible for the survey work in the organized forest districts.

1. Ottawa Division of the Forest Insect Survey.

The insectaries of the Ottawa division of the survey are located in the Arboretum of the Central Experimental Farm. Practically all tree species found in Ontario are represented in the arboretum and this has an important bearing on handling insect samples recovered from [illegible] species peculiar to the southern counties.

The survey is conducted in very much the same manner as in other laboratories; collecting boxes are distributed to representatives of the Department of Lands and Forests, particularly to those members who have keen powers of observation and a natural aptitude for collecting. The Ottawa laboratory, however, is placing more reliance and greater responsibilities on its own forest insect rangers. Two members of the staff have been assigned to this work and over a period of years they have become familiar with most of the common forest and shade tree insects in the province; they know the location and personnel of the principal provincial forest nurseries and plantations as well as county forests, recreation centres, and demonstration woodlots. Within recent years, survey collections and inspections have been extended to cover reforestation projects of the Ontario Hydro Electric Power Commission.

The number of forest and shade tree insect species occurring in Southern Ontario is probably greater than in any other territory due to the large variety of coniferous and deciduous trees occurring in that area. Our rangers, although encouraged to take samples of shade tree insects, are asked to pay special attention to insects affecting young trees in nurseries and plantations in view of the great demand for nursery stock. Particular attention is devoted to species of foreign origin recently established in the Province; the European pine shoot moth, the European spruce sawfly and the pine sawfly (*Neodiprion sertifer* Geoff.) are three good examples. It is advantageous to know the distribution of an introduced species especially when it involves the establishment of natural control agents such as parasites and diseases.

Sampling of [illegible] windbreaks and shelter-belts and inspection of [illegible] are also carried out and our rangers report that this service is generally greatly appreciated; upon receipt of the specimens at headquarters, the property owners are advised of the [illegible] identification. The number of samples received in 1946 [illegible] of over 500 compared with the number submitted in 1945.

2. Sault Ste. Marie Division of the Forest Insect Survey.

The field and laboratory work connected with the Forest Insect Survey has increased tremendously during the past two years. A measure of the increased activity in 1946 is provided by the number of survey samples received at the laboratory for analysis and rearing; namely, 3950 sample boxes received, the contents of which when sorted over in the laboratory were set up in no less than 19,000 rearing lots. Prompt acknowledgment of each sample collection was sent out to the collector, and monthly summaries of these collections, with a statement of conclusions drawn from the samples and from observations made in the field by the Forest Insect Rangers, were distributed periodically to all District Foresters, and to a number of other key personnel in co-operating services.

The establishment of reference collections of adult forms of forest insects and their parasites has continued, and further progress has been made in the problem of associating the immature and adult forms of the many species encountered. This is an extremely important phase of the Forest Insect Survey work because most forms are submitted in an immature stage, and their recognition depends upon a knowledge of the association between immature and adult stages.

Contributions to the knowledge of important forest insects in Ontario in 1946 have already been noted in the appropriate parts of Section II. Additional data have been gathered on many species of lesser importance, and on other species not currently epidemic. A detailed review of these general activities will not be attempted here.

One development of the Forest Insect Survey warrants especial attention; namely, the establishment and organization of the Forest Insect Rangers. The employment of Forest Insect Rangers to intensify the activities and to improve the efficiency of the Forest Insect Survey is a comparatively recent development. Starting with two rangers (employed by the Ontario Department of Lands and Forests) attached to the Sault Ste. Marie Laboratory in 1944, the number increased to seven rangers in 1945, and to fifteen rangers in 1946. These 15 rangers were employed in 14 of the forest districts established by the Department of Lands and Forests, certain of the rangers working in pairs in two or three adjacent districts. The ultimate aim is to have one ranger permanently assigned to a particular district, although in a few instances (e.g. Sioux Lookout District) efficient ranger coverage may require the services of at least two rangers.

The activities of the rangers in their respective districts are manifold, but may be outlined briefly as follows:

i) To maintain contacts with all personnel in the Department of Lands and Forests, and in the forest industry within the district for the purpose of providing information on insect conditions and instructing in methods of making collections and assessing intensity of infestations and damage.

ii) To accomplish, personally, general coverage throughout as much of the district as possible. By "coverage" is meant the collection of insect samples, assessing the extent and intensity of infestations, and securing concrete data on stand composition, and on damage to the various size classes of the affected timber species.

iii) To carry out special surveys to provide information on particular stands or areas, as required by the Department of Lands and Forests, the forest industries, or other institutions.

iv) To provide mass collections of insects for special research by other members of the laboratory staff (investigations in genetics, in insect pathology, in parasitism, in physiology and physical ecology, etc.).

Many permanent sample plots are being established in the districts for the regular periodic assessment, by special methods, of insect populations. These plots are being established in various forest types, and will be sufficiently distributed throughout the district to provide a representative coverage of the forests therein. Much of the future work of the rangers will therefore be devoted to the re-examination of conditions on these sample plots, but it is not intended that this activity will preclude attention to their other duties as outlined above.

In the development of the Forest Insect Ranger Service, it is intended that each ranger will eventually have a grasp of all important forestry and entomological matters within his district, including forestry personnel, methods of travel and communication, development in the industrial units, the distribution and extent of forest types, and insect conditions throughout the district as well as in stands of particular value. Such an objective will provide full scope for the development and increased efficiency of each ranger.

A general summary of the Forest Insect Ranger work throughout the Province in 1946 is given below. Contributions to the knowledge of specific insect infestations have already been included in the appropriate portions of Section II.

Each ranger or team of rangers working in adjacent districts is equipped with motor transport (heavy duty army vehicle), canoe and outboard motor, and a complete camping outfit, as well as special equipment for collecting insect samples and laying out sample plots. Travel throughout the districts is accomplished by making use of all available roads, and navigable streams and lakes. For access into more remote territories, very considerable reliance is placed on the excellent co-operation received from the Provincial Air Service. Accommodation has been generously provided by the Department of Lands and Forests at its various ranger stations, etc., as well as by logging camps of the pulp and paper and lumbering firms. Frequent co-operation has also been received both from the Department of Lands and Forests and from private firms in attaching personnel to the Forest Insect Ranger on special trips in the woods, particularly where extensive water travel is involved.

A quantitative measure of the activities of all personnel in the various forest districts in the Forest Insect Survey in 1946 is shown in summary form in the attached table. The number of survey samples received from each forest district has been broken down into the number contributed by various co-operators, and it will be seen that in some districts very good co-operation has been provided. In other districts however, there is still room for considerable intensification of effort in the Forest Insect Survey, and this applies particularly to the participation of private companies in this important work.

Summary by Forest Districts of Insect Collections Submitted from all Sources and Contacts made by Forest Insect Rangers with Co-operators - May 1 - September 30, 1946

Personnel Involved		Sioux Lookout	Kenora	Fort Frances	Port Arthur	Geraldton	Kapuskasing	Cochrane	Sault Ste. Marie	Chapleau	Gogama	Sudbury	North Bay	Parry Sound	Algonquin	Totals
Forestry Personnel Independently	Number of Collections	17	107	28	115	15	130	82	145	21	30	106	134	81	62	1069
	Number of Personnel Involved	7	67	9	17	5	23	25	51	16	23	22	40	38	28	371
Forestry Personnel with Insect Rangers		50	116	74	14	23	31	32	67	14	21	6	57	6	3	514
Insect Rangers Independently		166	68	60	250	154	188	88	357	135	71	208	123	94	98	2060
Other Co-operators		10	8	4	18	11	12	7	52	0	3	0	2	1	11	139
Number of Personnel Contacted by Insect Rangers		46	72	31	60	32	33	85	97	36	43	32	74	36	42	719

North Bay - Parry Sound - Algonquin Park

Forest Insect Rangers W. J. Miller and D. G. MacGillivray were engaged in the North Bay-Parry Sound-Algonquin Park Forest Districts from May 3rd to October 28th, 1946. Air travel was provided by the Provincial Air Service to the extent of approximately three hours in the North Bay Forest District. In addition, excellent co-operation was given in the provision of boats and motors for water transportation in the North Bay District.

Contacts with Department of Lands and Forests personnel in the three Districts were made as follows: North Bay Division, 24; Timagami Division, 26; Elk Lake Division, 24; Algonquin Park north, 21; Algonquin Park south, 21, Parry Sound, 13; Nowassan, 23. On the average, three contacts were made with each person during the season.

Survey samples were submitted to the Sault Ste. Marie Laboratory from the Districts as follows: North Bay, 316; Parry Sound, 182; Algonquin Park, 174. A considerable proportion of the samples submitted came from the co-operators.

North Bay -- The insect considered to be of major importance in the North Bay District in the current season was the jackpine sawfly, Neodiprion swainei, which occurred in light to heavy infestations in the area west of Lady Evelyn Lake in Timagami Division. The heaviest concentrations of the insect occurred in the Townships of Strathewey, Whitson, Roucke, Straden and Keith. The spruce budworm has caused a heavy mortality in balsam fir and white spruce in the southern portion of the North Bay District but has now declined to very small numbers. A heavy infestation of the fall webworm on cherry, alder, birch and willow in the North Bay District extended from Lake Timagami southward to Lake Nipissing and the French River. Heavy infestations of the eastern tent caterpillar on red cherry occurred in the vicinity of North Bay and Dunnet Township. Medium defoliation of balsam fir in MacNish Township of the North Bay Division by the hemlock looper is reported.

A special survey in connection with the jackpine sawfly infestation in the Lady Evelyn Lake area was carried out. The infestation was mapped by ground and aerial reconnaissance; population counts were made; and forest composition strip tallies run to ascertain the mortality in jackpine stands.

Algonquin Park -- A heavy infestation of Leconte's sawfly at Burnt Island Lake in Maclaughlin Township caused complete defoliation in one small area of approximately two acres. Medium infestations of the red pine sawfly, Neodiprion nanulus, occurred in the area extending from Pembroke westward to the Townships of Burns and Sherwin. The infestations are active in small patches of red pine regeneration. Heavy infestations of the fall webworm were prevalent with the heaviest concentrations occurring in the vicinity of Pembroke. Heavy infestations of the eastern tent caterpillar on

red cherry occurred in five townships immediately surrounding Pembroke in the Algonquin District.

Parry Sound -- The spruce budworm has been reported in two small areas in the Parry Sound District. In the first of these (Laurier, Jolly and Strong Townships), the infestation is light with heavy mortality resulting from previous years' defoliation; in the second (Spence and McKellar Townships), the infestation is light and no mortality is reported. An infestation of the eastern tent caterpillar extends throughout almost the entire length of the District from the Township of North Himsworth in a band on either side of the Canadian National Railway southward.

Mass collections of red pine and Leconte's sawfly were submitted to the Sault Ste. Marie Laboratory for pathological studies. Larval and pupal collections of Swaine's sawfly were submitted to the Forest Insect Survey for determination of parasitism in the infestations and also for pathological studies. In addition, numerous mass collections of the eastern tent caterpillar were submitted for pathological and parasitic studies.

Sudbury - Gogama - Chapleau.

H. R. Foster and F. A. Bricault carried out forest insect ranging activities in the Sudbury Chapleau Gogama Forest Districts from May 2nd to October 14th. These three districts were handled jointly in 1946, Sudbury being used as a centre of operations for the combined territory. Air travel was contributed by the Provincial Air Service in the three districts to the extent of approximately thirteen hours flying time, and by the private air service of the Wakami Lumber Company to the extent of one and one-half hours flying time in connection with an aerial survey of the jackpine budworm infestation in the Sultan area. The Department of Lands and Forests also contributed material assistance in launch and land travel throughout the season.

Sudbury -- In the Sudbury Forest District, Department of Lands and Forests personnel were contacted to the number of 13 in the Sudbury Division; nine in the Webbwood Division; and six in the Skead Division, with an average of approximately six contacts per person throughout the season. Four co-operators in the pulp and paper industry were also contacted. 320 survey samples were received at the Forest Insect Laboratory, Sault Ste. Marie, from the Sudbury District in 1946.

The spruce budworm which has been active in portions of the Sudbury District in recent years has now declined to very negligible proportions, and no active infestations persist, so far as is known, within the boundaries of this District. Similarly, the jackpine sawfly which, approximately fifteen years ago, was in outbreak proportions in the northern part of the District, was not found in any importance in 1946. Local infestations of the american tent caterpillar were found on wild cherry in the southern portions of the District, chiefly in Shedden Township and north of McGregor Bay. However, the infestation was not found on commercial timber species.

The striped mapleworm infestation on Manitoulin Island which has been active during the past six or seven years and particularly severe in 1945 in the Sandfield-Kindemoya Lake region, suffered a considerable decline in intensity in 1946 over the whole area with the greatest concentrations this year confined to a small area south of Manitou Lake near Sandfield. Insect Rangers A. G. McDonald and A. L. Rose of the Sault Ste. Marie District participated in the work on Manitoulin Island with Messrs. Foster and Bricault in 1946. Mass collections of the striped mapleworm were made in the larval stage and in the pupal stage for determination of the importance of disease microorganisms and of parasites in the natural control of this species.

Swaine's sawfly has been found in light infestation in the section of the District extending north from Chapleau Lake. The yellow-headed spruce sawfly was in heavy outbreak on black spruce trees along the shore of Mohzabong and Lusamasin Lakes in the upper portion of the Sudbury District as well as in other parts of the Chapleau-Gogama Districts. Considerable killing of these shore-line black spruce trees was recorded at the above mentioned lakes.

Gogama -- In the Gogama Forest District personnel of the Department of Lands and Forests were contacted during the season to the extent of 22 in the Gogama Division and 14 in the Foleyet Division, each person being contacted, on the average, three times during the season. In addition, seven co-operators in private industry within the District were contacted in connection with the Forest Insect Survey. 125 survey samples were submitted to the Sault Ste. Marie Laboratory from the Gogama District in 1946.

The spruce budworm has been active in the Gogama Forest District for a number of years, and still persists in medium to heavy infestation over much of the territory as shown in the map of spruce budworm infestations referred to earlier in this report. Swaine's sawfly has been found in light infestations in jackpine stands south of Gogama. Mass collections of spruce budworm larvae from

the Gogama District were submitted to the [illegible] laboratory for pathological studies, and special surveys in connection with the deterioration of jackpine stands were carried out in Ogilvie, Pennewabi and Nerdiamo townships of this District.

Chapleau -- In the Chapleau Forest District, Department of Lands and Forests personnel were contacted to the number of 15 persons in the Biscotasing Division, and 11 in the Chapleau Division, with an average of approximately five contacts per person during the season. Five co-operators in the forest industries were also contacted during the season. 170 sample collections were contributed from the Chapleau District in 1946, the greater bulk of these by Forest Insect Rangers. Much of the mature balsam spruce timber in the Chapleau Districts has been killed by earlier spruce budworm outbreaks, but medium to heavy infestations persist in the vicinity of Wenebegon Lake eastwards to Township Four. In addition, light infestations are found throughout most of the District.

The jackpine budworm has been found in active infestation in the vicinity of Sultan, but is elsewhere [illegible] very light throughout the district. Mass collections of the jackpine budworm have been submitted from the vicinity of Sultan for studies of sex ratio, disease and parasitism. It is also noteworthy that spruce budworm affected by fungous diseases were recovered from the Chapleau District in 1946.

Sault Ste. Marie District.

Forest Insect Rangers A. G. McDonald and A. L. Rose were engaged in the Sault Ste. Marie Forest District from May 1st to October 15th, 1946. Air travel was provided by the Provincial Air Service to the considerable amount of 84 hours flying time, and by the Photographic Survey Company to the extent of six hours, in connection with experimental photography of budworm-infested areas and others where mortality from earlier attacks has occurred.

The Department of Lands and Forests also provided facilities for travel by water throughout the District. Department of Lands and Forests personnel in the Blind River Division, Sault Ste. Marie Division, A. C. R. Division, Franz Division and Mobert Division, were contacted in the following numbers respectively, 19, 22, 9, 13 and 18. An average of approximately four contacts with each person was made during the year. 16 co-operators in the pulp and paper industry were also contacted.

A total of 621 survey samples were submitted from the Sault Ste. Marie District in 1946, a considerable proportion of which were submitted by forestry and other co-operating personnel.

The spruce budworm [illegible] to be active in the northern portion of the Sault Ste. Marie District with light infestation occurring throughout the entire area. Small pockets of heavy infestation occur throughout the Franz Division and notably in the vicinity of Oba Lake and Missinaibi Lake, as well as in the

Townships of Jones, Cooper, Glasgow, Meath, Rennie and Leeson An extensive heavily infested area extends from Black River on the west to Magone and Common Townships in the east in the Mobert Division. The only active infestation of the insect in the southern half of the District occurs at Tikamaganda in Township 25 Range 18 of the A. C. R. Division.

The striped mapleworm which was very active on St. Joseph Island and in the vicinity of the Lonely Lake Forestry Station headquarters in Sault Ste. Marie Division has shown a marked decline in numbers in 1946. Leconte's sawfly which was very active a number of years ago in the Kirkwood Plantation, north of Thessalon, and which caused considerable mortality in nursery red pine in that area, was found in three areas in 1946. namely, MacDonald, Calbraith and Kirkwood Townships. The basswood looper which has been prevalent on deciduous trees in the southern portion of the Sault Ste. Marie District for several years continues to be widespread, presumably in small numbers except in the vicinity of Point Lake where extensive defoliation has occurred.

Special tallies to ascertain mortality through the activities of the spruce budworm in the Tikamaganda Lake area were made.

Mass collections of spruce budworm for pathological and cytogenetic studies and sex ratio determinations were submitted. Mass collections of larvae and pupae of the green striped mapleworm, and larval collections of the red humped oak caterpillar, were also submitted for determination of the disease microorganisms present in the populations.

Cochrane - Kapuskasing.

Forest Insect Rangers H. G. McPhee and G. A. King carried out ranging activities in the Cochrane-Kapuskasing Districts from May 17 to October 23, 1946. Air travel within the two Districts was contributed by the Provincial Air Service to the amount of 27 hours, and launch travel to the amount of 16 hours. Department of Lands and Forests personnel were contacted in the various Divisions as follows: Kapuskasing, 18; Hearst, 7; Oba, 8; Cochrane, 17; Abitibi, 12; Swastika, 11; Timmins, 12; with an average of about three contacts per man per season. In addition, co-operators in the pulp and paper industry were contacted to the number of 33.

Cochrane - 209 insect collections were submitted to the Sault Ste Marie Laboratory from the Cochrane District. The infestation of the spruce budworm in the Cochrane District has been showing some intensification with areas of heavy to severe infestation in the vicinity of Abitibi Lake, Kapuskasing Lake, Timmins, Cochrane, Little Abitibi Lake and the Abitibi River west of Little Abitibi Lake. Infestations of this insect were found to extend as far as Moose River Crossing near James Bay, but no serious defoliation

has occurred at these localities [illegible] outbreak of the forest tent caterpillar [illegible] small numbers throughout the District and [illegible] of the jackpine sawfly have been found in the southern portion of the District in the vicinity of [illegible]. Aspen stands extending from Timmins eastward to the Quebec border were affected by an ink-spot disease of the foliage causing premature browning in early summer.

Mass collections of spruce budworm larvae and of forest tent caterpillar for pathological studies, and of spruce budworm eggs for bee fabic studies were submitted to the Forest Ste. Marie Laboratory.

Tallies in stands affected by the spruce budworm to determine mortality to date, were carried out in the vicinity of Timmins, southeast of Cochrane, [illegible] and north of Smooth Rock Falls.

Kapuskasing — 301 insect collections were submitted to the Forest Ste. Marie Laboratory from the Kapuskasing District.

The spruce budworm infestation occurs throughout the entire District with several areas of medium to heavy intensity, chiefly north and south of Kapuskasing, and southwest of Hearst. An extensive area of medium infestation merging to heavy at the southern extremity extends from the Townships of Rogers and Fushimi in the north, to Lessard, Wicksteed and Haig in the south.

Small numbers of the red pine and jackpine sawfly and Swaine's sawfly were found on jackpine in McCoig, McMillan, Franz, Hawkins and Hayward Townships, although no serious infestations have been discovered as yet.

Mass collections of the spruce budworm and the jackpine sawfly were submitted to the Laboratory for pathological study. Special examinations have been made for spruce budworm damage to date in the following locations: north and south of Kapuskasing; south of Hearst; near Oba, and along the Pagwachuan River in the western part of the District.

Geraldton District.

Mr. Perry Teatro carried out Forest Insect Ranging duties in the Geraldton District from May 23rd to October 10th, 1946. Department of Lands and Forests personnel were contacted to the extent of six in the Nakina Division, seven in the Long Lac Division and five in the Pays Plat Division, with an average of about three contacts per man per [illegible]. In addition, [illegible] employees in pulp and paper [illegible] were contacted in connection with the Forest Insect Survey. Air travel throughout the District was given by the Provincial Air Service to the total of 37 hours flying time. A total of 203 survey samples were submitted from the Geraldton District.

The [illegible]

District is that of the spruce budworm which has now extended well into the District from the Lake Nipigon infestation centre. Heavy infestations now occur generally through the western and northwestern portions of the District, extending east of Long Lake. Medium infestations extend another 30 to 35 miles to the east, especially in the vicinity of Aguasabonan Lake and the upper head waters of the Pic River. In addition, medium to heavy infestations occur on the eastern border of the Geraldton District as extensions of the infestations in the Kapuskasing and Sault Ste. Marie Districts.

The jackpine budworm has been recorded only in very light numbers in the Geraldton District in 1946. The larch sawfly occurs in light infestations in scattered larch swamps along the Lake Superior shore between Schreiber and Nama and the yellow-headed spruce sawfly on black spruce trees growing along lake shores and other exposed places, but no important damage has been observed.

Special tallies have been made to assess present mortality due to budworm infestations in Leggatt Township west of Geraldton; at Twin Lakes east of Nakina, and on Highway 11 at the extreme eastern point of the Geraldton District.

Special collections of egg masses were submitted for sex ratio studies, and of young [illegible] larvae for pathological studies at the Sault Ste. Marie Laboratory.

Port Arthur District.

Forest Insect Ranger Angus Harnden spent the period May 17th to October 11th, inclusive, in carrying out ranger activities in the Port Arthur Forest District. The Provincial Air Service contributed to the execution of this work to the extent of 10 hours flying time in connection with ranging duties, and an additional 20 hours in connection with aerial mapping of spruce budworm infestation.

Personnel in the Department of Lands and Forests contacted during the season comprised 11 in the Fort William Division, 10 in the Shebandowan Division; 9 in the MacDiarmid Division, and 9 in the Black Sturgeon Lake Division, the average number of contacts per person being close to three. In addition, 21 co-operators in the pulp and paper industry were contacted. 397 survey samples were submitted to the Laboratory at Sault Ste. Marie from the Port Arthur District.

The outstanding forest insect problem in the Port Arthur District is the extensive spruce budworm infestation centered around Lake Nipigon. Heavy infestation and damage by this insect were also found on the northern side of Pie Island lying in Thunder Bay. The aspen leaf miner was in heavy infestation

throughout the entire District, and, in addition, the aspen tortrix caused heavy defoliation in scattered aspen stands south of Fort William to the American border. The larch sawfly which has previously occurred in infestations in this District was in 1946 in light population intensity between Fort William and English River.

Mass collections of spruce budworm larvae were sent from various parts of the Fort Arthur District to the Sault Ste Marie Laboratory for pathological investigations, and a collection of eggs and newly hatched larvae for studies of sex ratio in the field population. Special surveys were made in the Georgia Lake area south of Orient Bay to investigate mortality in mixed balsam-spruce stands resulting from budworm attack; in the vicinity of Argon to investigate mortality in jackpine stands near Dog Lake where heavy infestation of the jackpine budworm occurred in 1939, and in the vicinity of Dearsmore in mixed stands containing a high proportion of balsam fir and spruce to determine present mortality resulting from spruce budworm attack.

Kenora - Fort Frances.

Forest Insect Rangers J. M. Bussineau and L. S. MacLeod were active in the Kenora - Fort Frances Districts from May 15, to October 9, 1946, inclusive, for the most part working jointly in the two Districts.

Kenora -- Assistance in travel through the District was provided by the Department of Lands and Forests in respect of air travel to the amount of 13 hours flying time, and in launch travel, on some of the larger lakes, to the extent of about six hours travelling time.

During the season, personnel in the Department of Lands and Forests were contacted repeatedly to the extent of 39 men in the Kenora Division; 15 men in the Minaki Division; 8 men in the Ignace Division. In addition personnel in the pulp and paper firms were contacted as opportunity permitted. 299 survey samples were submitted to the Forest Insect Survey at Sault Ste. Marie from the Kenora District.

The jackpine budworm which had been in epidemic conditions during the late 1930's and early 1940's and which resulted in considerable killing of jackpine, was in 1946 scarce throughout the District. The larch sawfly is in outbreak proportions over much of the territory from Ignace westward to the vicinity of Kenora, with areas of concentration in the vicinity of Eagle River, and in Melick Township north of Kenora. The spruce budworm is attacking balsam fir and spruce in the Mabigoon River and Big Canon Lake area, representing the presently known southern

extension of the extensive outbreak lying to the south and west of Lac Seul. The white pine weevil is an enemy of immature jackpine causing killing of tops throughout the District, though not in excess of about five percent in any area. White birch on numerous islands in Whitefish Bay of Lake of the Woods was almost totally stripped by the birch sawfly in 1946 as also in 1945. Widespread infestation of the aspen leaf miner occurred on trembling aspen throughout the entire district, causing premature yellowing and dropping of the foliage.

Special attention was given by Forest Insect Rangers in the Kenora District to the examination of jackpine stands for deterioration resulting from previous jackpine budworm outbreaks, and in one area, from procupines; and to the evaluation of importance of parasites in the natural control of the larch sawfly.

Special collections of larch sawfly, yellow-headed spruce sawfly and the birch sawfly were submitted from various parts of the Kenora District for pathological study at the Laboratory in Sault Ste. Marie.

Fort Frances -- Forest Insect Ranger service in the Fort Frances District extended from June 14, 1946, to September 1, 1946, inclusive. 31 co-operating personnel in the District were contacted on an average of three times throughout the season. Air travel provided by the Provincial Air Service amounted to 14 hours flying time. The Department of Lands and Forests also assisted in launch travel on Rainy Lake (7 hours), and in the provision of canoes and outboard motors periodically throughout the summer. 166 survey samples were submitted from the Fort Frances District.

The Fort Frances District is possibly exceptional in that no known infestations of the spruce budworm occur in this District. In fact, only one specimen of the spruce budworm was recovered in survey samples from this District in 1946. This was obtained in a mixed stand of white spruce and balsam fir in the vicinity of Beaverhouse Lake. The hemlock looper, yellow headed spruce sawfly and various sawflies on redpine and jackpine as well as the hemlock looper were recovered in the District, but not in infestation conditions. The only infestation, which is nevertheless of light intensity in 1946, was that of the larch sawfly in scattered swamps occurring in the western portion of the District.

Mass collections of the larch sawfly and of the yellow-headed spruce sawfly were submitted from the Fort Frances District for pathological studies at the Sault Ste. Marie Laboratory. A special examination of jackpine stands in the Turtle River-Ultrut Lake region was carried out to determine the extent and cause of deterioration observed by Major-General Howard Kennedy. Reference to the findings of this special survey are included in another section of this brief. Similar examination of jackpine stands was made at Eva Lake, south of Kawene on the Canadian National Railway

Forest Insect Rangers S. W. Lukinuk and G. R. Carter spent the period May 24, 1946, to September 20, 1946, inclusive, in the Sioux Lookout Forest District. Accommodation for these two Rangers was provided by the Provincial Air Service at Sioux Lookout, which was adopted as seasonal base for the operations in this territory, although extensive travel throughout the entire District was carried out by means of air travel, water travel, and travel overland to some extent. The aircraft of the Provincial Air Service stationed at Sioux Lookout, Red Lake, Pickle Lake and Armstrong were provided for Forest Insect Ranger activities to a total of approximately 32 hours flying time. Extensive infestations of the spruce budworm and the jackpine budworm in the Sioux Lookout District were mapped by means of aerial reconnaissance. 239 survey samples were submitted from the Sioux Lookout District in 1946. Co-operating personnel in the Sioux Lookout Division, in the Red Lake Division, in the Armstrong Division and the Pickle Lake Division, were contacted in the following numbers, respectively: 21, 6, 12 and 7.

The spruce budworm occurs in infestations west of Lac Seul; in the vicinity of Sioux Lookout - Hudson, and the northern extension of the Lake Nipigon outbreak enters the Sioux Lookout District at the extreme east. The jackpine budworm occurs in infestation southwest of Red Lake. Larch sawfly infestations occur in scattered stands of larch throughout the District, with greatest intensity south of Trout Lake and in the vicinity of Sioux Lookout. A heavy but local infestation of the hemlock looper occurs in the Sioux Lookout District at Budgin Lake, which lies south of Ionsford Township between Pickle Lake and Lake St Joseph.

The Forest Insect Rangers in the Sioux Lookout District provided material of unusual interest to other investigators on the Laboratory staff, particularly samples of diseased hemlock loopers from Budgin Lake for pathological studies; samples of jackpine budworm material from the western territories for cytogenetic investigations; and newly hatched spruce budworm larvae for determinations of sex ratio.

G. R. Carter also spent a period of four weeks in the Wabigoon - Big Canon Lake area assisting in the establishment of an investigative crew working in that territory in connection with analysis of budworm infestations in relation to stand composition and condition of balsam fir.

PROPOSED DEVELOPMENT IN ORGANIZATION AND PROGRAM OF SURVEYS AND RESEARCH.

References to forest entomology in the Province of Ontario up to the year 1946 would be incomplete without some reference to proposed developments in organization and program of work intended for the future. This cannot be forseen with exactitude because of the present difficulties in acquiring technically trained staff, and in the present shortage of certain types of equipment and supplies. However, the general outline of proposed developments can be given without difficulty.

The activities of the staff attached to the Angus Field Station will be redirected to a study of insects affecting forest nurseries, plantations, woodlots and shade trees in Southern Ontario, with particular reference to the discovery of effective control measures so that infestations can be controlled promptly and effectively.

The program of work undertaken by the Forest Insect Laboratory at Sault Ste. Marie will be intensified both with regard to fundamental problems and to the conduct of the Forest Insect Survey. Fundamental studies will be undertaken in insect ecology and physiology in the meteorological factors affecting insect survival and dispersal, and in the climatological factors affecting adaptability of insect pests in different territories, and the probability of their becoming destructive therein. Fundamental studies will also be conducted in various biometrical aspects of the field problems relating particularly to the development of adequate sampling techniques for determining population levels, and evaluating the importance of factors of natural control. Investigations in insect pathology, cytogenetics and other highly specialized fields, will be continued on an intensified basis. Such fundamental studies will be conducted on as wide a variety of economic problems as can be handled, and should contribute materially to an understanding of the processes involved in the epidemiology of forest insects in Ontario.

It is apparent from the outline of projects in operation in 1946 given in the preceding section of this brief, that a great proportion of available effort has been devoted to the spruce budworm problem in recent years. This is as it should be under prevailing conditions of insufficient staff to cover other problems adequately, but we must not lose sight of the existence of a large number of other problems which, if not so pressingly important as the spruce budworm problem at the present time, are nevertheless intricately involved in the conservation of important timber species.

Certain aspects of the spruce budworm problem have yet to be developed satisfactorily in Ontario. These include a thorough study of the chronology and distribution of pest outbreaks of this species, much

evidence being available in the ring history and crown development of trees surviving these past outbreaks. Forest entomological staff engaged in Ontario during previous recorded outbreaks was so inadequate that it was not possible even to determine accurately the areas affected, and practically nothing is known of the extent of damage caused. Again, in addition, there is some evidence of far older outbreaks, of which there is no written record so far as we know, which swept through various parts of the Province at successive intervals. These old outbreaks, unrecorded and recorded alike, have undoubtedly affected the forest stand very greatly, and it is of great importance to determine as accurately as possible the changes which have been brought about in the forest as a result of these former outbreaks, such information being of considerable importance in connection with any plans ultimately adopted for regulation of the forest under principles of management.

Another aspect of the spruce budworm problem which should be studied as intensively, has to do with the rapid accumulation of as much information as possible relating to recent and current damage in stands of different ages, species composition, physiological state, etcetera, so that a reasonably accurate evaluation of hazard may be obtained. A start was made in 1946 with a ground survey party working in the Algoma region. Similar work should be conducted in other portions of the Province where stand conditions and the infestation history differ. The experimental work initiated in the fall of 1946 in the application of aerial photography to the detection of infestations, and the measurement of damage to the timber, should be pushed as rapidly as the techniques will permit the accumulation of the required information. The Forest Insect Laboratory is most anxious and willing to contribute in this work to the full extent of its ability, particularly in connection with the cross checking between interpretation of the aerial photographs and actual conditions on the ground in the areas under study.

Recent depredations caused by the spruce budworm must provide sufficient evidence of the need for the utmost efforts in preventing repetition of this scourge as soon as the forest is once more in a condition to favour another outbreak. It would be unwise to expect that measures of chemical control, or even more promising, of biological control will provide a cure for all future outbreaks and thereby obviate the necessity of making some change in the forest itself. Although one cannot, at this time, outline in detail the factors which contribute to high hazard to the forest by the spruce budworm, it is safe to say in general terms that balsam fir, especially when present in high densities and in over mature condition, is one of the principal factors promoting outbreaks. Ultimately, intensive research should make it possible to define hazard conditions more precisely, but it will undoubtedly be a mistake to defer concrete action in forest management as a means of minimizing budworm damage until all the factors are satisfactorily understood. What is greatly needed in the Province of Ontario is the commencement of a management project on as large an area as can be handled satisfactorily, and in which the combined efforts of foresters, entomologists, and specialists in woods utilization will be directed to the gradual development of the forest into a suitable distribution of age classes and timber species such as to provide for perpetual operation with outundue risk of insect devastation. It is to be hoped that suitable

arrangements towards such an objective can be worked out between the Department of Lands and Forests and some industrial firm to permit an early start in this tremendously important project.

Other forest insect problems which require study in the Province include:

i) The jackpine budworm which has been active in the western region since about 1935 and is once more resurgent over a very wide portion of the Sioux Lookout forest district, and which will undoubtedly reappear more widely through the important jackpine forests of northern Ontario from time to time.

ii) The bronze birch borer in relation to deterioration of white and yellow birch in various parts of the Province. The yellow birch in particular is very valuable as a source of high quality timber for use in the furniture industry. The destruction caused to yellow birch in New Brunswick by series of factors, of which the bronze birch borer is one, both cuts off the source of supply of suitable timber for importation into Ontario, and also provides striking evidence of how seriously such devastation may affect the forest resources of a region.

iii) The white pine weevil is a factor limiting the possibility of establishment of white pine plantations in portions of Ontario where this valuable timber species once was predominant. The work which was under taken in the vicinity of Chalk River some ten years ago and dropped, of necessity, due to staff reductions during wartime, must be initiated once more to try to find a definite answer to the question of the degree of protection provided by overstories of birch, aspen or other species, and in addition, the possibilities of control by chemical means, or otherwise, should be more thoroughly explored. The Forest Insect Unit can also contribute materially to a program being undertaken by the Department of Lands and Forests in an attempt to produce suitable strains of white pine for plantations by critical assessment of various strains, with particular reference to their ability to withstand attack by the weevil without undue damage.

iv) Insects affecting stands of larch in the Province should receive much additional study. This important timber species was virtually eliminated from all of eastern Canada several decades ago through the activities of the European larch sawfly, and this destructive pest is once is once more building up infestations in the young stands of larch which have become established after the destruction of the former mature stands. The parasites, which apparently were so successful in combatting this pest some twenty to thirty years ago, appear to be at rather a low ebb in Ontario at the present time, and additional work in the biological control of the larch sawfly is urgently needed.

The larch casebearer, while not usually regarded as a devastating pest of larch, is now widely epidemic in the larch stands of northern Ontario and may be an important factor in the ability of such stands to withstand attack by the larch sawfly.

v) The native sawflies attacking various species of pine and spruce periodically recur in severe outbreaks and should be investigated much more intensively, particularly with regard to the possibility of

establishing effective biological control, either through parasites or disease microorganisms.

vi) The role of insects in the dissemination of the dutch elm disease under conditions in Canada requires much more intensive investigations in view of the evident differences in the insect-fungus-tree relationships in Canada and the United States. The problem is presently very serious in the Province of Quebec, and there seems little reason to expect that elm in the south portions of Ontario may escape. Whether measures of control can be devised cannot be forecast without a clear understanding of the role of insects in dissemination of the disease.

There are many additional problems which must be investigated including the role of various defoliating insects in hardwood stands, the role of insects in relation to seed production of coniferous tree species, especially of white and red pine where insects appear to be very important in limiting the supply of viable seed; and others.

Ability to pursue these lines of investigation will be limited until an adequate staff of trained men is available. These can only be developed gradually as a joint project of the Universities and of the Forest Insect Investigations Unit, as both academic training and experience under close direction are vitally important in the development of competent investigative personnel in forest entomology. Every encouragement should, therefore, be provided for the early recruitment of young undergraduate students for seasonal employment in forest entomology so that their applied training may be started as soon as possible.

Further development of the Forest Insect Ranger Service and other activities of the Forest Insect Survey will be in refinement of method, and extension of coverage, rather than in any fundamental change in the activities now undertaken. Additional Forest Insect Rangers should be added to permit the assignment of one Ranger to each forest district; as the forest districts under administration of the Department of Lands and Forests are increased in number by reduction in size, there should be a corresponding increase in the number of Forest Insect Rangers. This will permit each Ranger to be definitely assigned to a territory recognized as an administrative unit by the Department of Lands and Forests, thereby simplifying intimate co-operation with forest district personnel in the matter of coverage, reporting, etcetera.

One of the major developments in the activities of the Forest Insect Rangers will be intensification of effort in connection with the periodic examination of permanent sampling plots to establish accurate trends of forest insect populations. Forest Insect Rangers will also be expected to determine, as accurately as possible, damage caused by forest insect outbreaks by means of special surveys, particularly in cases where such information may be of use in relation to salvage.

V

REVIEW OF THE FOREST INSECT PROBLEM AND ORGANIZATION IN ONTARIO, WITH RECOMMENDATIONS FOR FURTHER IMPROVEMENTS.

The broad relation of forest insects to the forest economy in Ontario, and some of the problems involved in attaining to a more an intimate understanding of the many factors governing the relationships between the insects and the forest, have been described in this brief.

Many of the forest insect problems are intensified by incomplete utilization of the forest, especially in the non-use over large areas of certain species considered inferior, or not in demand by the industrial unit holding lease to land in which such species may be growing. The existence of overmature and decadent forests over large areas encourages the development of forest insect outbreaks, and often the rapid killing of high value timber species in addition to those considered to be inferior. The complete solution of many forest insect problems can only be hoped for when forest land is brought under full management, and, in many cases, this will involve management over very large areas rather than over small parcels of highly productive forest land. To bring a large proportion of the Ontario forests under that degree of management required to reduce the danger of serious epidemics will, obviously, involve finding use for all the important timber species, and will also require that all parts of the forest are brought into operation. This may be possible by existing industrial units, but it may, in some regions, be necessary to favour the establishment of additional units so that the forest production of all areas may be utilized without the tremendous loss due to overmaturity, insect outbreaks, etc., which is now apparent through much of the Province.

To bring a large proportion of the Ontario forests under such management will obviously be a slow process, and a start will have to be made on a limited scale to determine the methods which can be used on a more extensive basis with the passage of time. During the preliminary stages of bringing the forests under management numerous outbreaks of forest insects will undoubtedly occur in unmanaged forests, and quite possibly also in small managed blocks of forest land, due to inadequate knowledge, and due to influences over which man has little or no control. It should be the responsibility of all co-operating organizations to suppress such outbreaks by the most appropriate means, whether by regulatory cutting, by the application of chemicals, or by biological methods.

The insect problems for which a solution may be found in the regulation of Ontario forests [illegible] include those whose origin can be related to [illegible] management of the forest. Such problems [illegible] the spruce budworm, the eastern spruce bark beetle, the [illegible] birch borer and possibly others. In these problems, direct control measures of several kinds have their place as temporary expedients, and may even provide satisfactory solutions locally and for a limited period, but they can hardly be expected to prevent recurrence of the problem in the absence of any fundamental change in the methods of handling the forest.

Some of the other major forest insect problems will undoubtedly recur indefinitely regardless of any changes in forest operations, and will have to be solved by various direct or indirect measures of control. The European larch sawfly, the European spruce sawfly and certain of the pine sawflies probably fall in this category since we have at present no definite indication that their destructiveness is related to the existence of unmanaged forests.

Others of the forest insect problems referred to in this brief cannot be placed definitely in either of the categories referred to in the preceding paragraphs, and in the present state of knowledge of the inter-relationships between the insects and the forests, it would serve no good purpose even to hazard a guess regarding their ultimate solution. The appropriate solution for each problem will only be attained after long and thorough research, of the most fundamental kind, in entomology, in forestry, and the related fields.

Although the forest industries are vitally affected, not only in immediate aspects of the forest insect problems in Ontario, but in their ultimate solution as well, by and large, with one or two notable exceptions, the various industrial firms are not at present sufficiently associated with the work in progress. This is not to be construed as lack of appreciation of the splendid personal relations between employees of the forest industries and of the Forest Insect Investigations Unit, or of the frequent material assistance in transportation, accommodation and other facilities provided by personnel of the industrial firms to forest insect rangers and investigational staff. The statement is rather an expression of disappointment that the forest industries, who so frequently request and receive the most recent information on insect outbreaks and damage derived from various investigative projects and particularly from the Forest Insect Survey, should be contributing so sparingly to this essentially co-operative activity. In certain of the Forest Districts of Ontario where virulent outbreaks are in progress and where, coincidentally, forest exploitation is very active, not more than a few forest insect survey samples were contributed in 1946 by all the industrial firms operating within these districts.

Forest insect work in the Province of Ontario falls into the following main categories (i) the Forest Insect Survey, (ii) laboratory and field research, (iii) work in connection with control

(i) The Forest Insect Survey in Ontario is conducted from the Ottawa Forest Insect Laboratory which is responsible for the southern part of the Province, and from the Sault Ste. Marie Laboratory which is responsible for the northern part of the Province, including most of the organized Forest Districts. This activity depends for its success upon continued co-operation of the Division of Entomology, the Department of Lands and Forests and the forest industries. A measure of the extent of the Forest Insect Survey, especially that section organized at the Sault Ste. Marie Laboratory, has been given in a previous section of this brief. It is the opinion of the officers responsible for the conduct of the Forest Insect Survey that a satisfactory start has been made in the establishment of the Survey on a basis which will ultimately provide the necessary information on extent and trend of insect infestations which, together with investigational work being carried on now and in the future, will permit effective action to prevent serious drain on the forest resources. As indicated previously, however, greatly increased participation of the forest industries in this activity is urgently required.

(ii) Research in forest entomology is carried out in Southern Ontario by the Division of Entomology at the Angus Laboratory, and in Northern Ontario at the Sault Ste. Marie Laboratory and its associated field stations. In addition, the Ontario Department of Lands and Forests undertakes a certain amount of investigation through its Division of Research, some of this being conducted jointly with the Division of Entomology.

(iii) Efforts in control of forest insects in Ontario have been carried out both by the Provincial Department of Lands and Forests and by the Division of Entomology. In direct control operations, the Department of Lands and Forests has taken the major responsibility in connection with large scale distribution of D.D.T. from aircraft. The Division of Entomology has contributed to this program through the assignment of technical supervisory officers in the field. Research in control methods involving chemicals has also been carried out by the Division of Entomology, especially in connection with the control of nursery pests, shade tree pests, and boring insects affecting unbarked logs left in the bush. In biological control, the Division of Entomology has contributed through the Dominion Parasite Laboratory at Belleville in connection with the propagation and dissemination of parasitic species; and through the Forest Insect Unit in connection with the study of disease-causing microorganisms. The latter program will be intensified just as soon as sufficient additional staff can be assembled. It will be very greatly promoted by the erection of a special laboratory for the study of insect pathology at Sault Ste. Marie.

Co-ordination of the activities of the Department of Lands and Forests and of the Division of Entomology in these various programs has been assisted through the enactment of a joint agreement of the "Crown Dominion", represented by the Minister of the Department of Agriculture, and of the "Crown Ontario", represented by the Minister of the Department of Lands and Forests, under date of April 28th, 1945. This agreement sets forth the condition under which the two Departments shall administer and arrange the program in forest entomology under the direction of the Sault Ste. Marie Laboratory. In brief, the "Crown Ontario" is responsible for maintenance and repair of the Laboratory building at Sault Ste. Marie, which was constructed at the expense of the "Crown Ontario". The "Crown Dominion" is responsible for equipping the Sault Ste. Marie Laboratory and for staffing it adequately for the purpose of carrying out the requirements of the joint agreement. The "Crown Dominion" and the "Crown Ontario" are jointly responsible for the establishment of an Advisory Committee, comprising three representatives of each Department, which Advisory Committee shall hold joint meetings periodically for the purpose of receiving reports and advising in respect of the work to be conducted in and from the Forest Insect Laboratory at Sault Ste. Marie. Provision was made in this joint agreement for subsequent review and revision, as may be mutually agreed to, by the two Departments, of the principal features of the agreement, from time to time at the request of either the "Crown Ontario" or the "Crown Dominion".

No proposed revisions in this joint agreement have as yet been suggested by either party in the agreement, and, therefore, such suggestions as are made below are included in this brief merely as an indication of what appears to be a possible course of action for the improvement of the co-ordination of work in the Province of Ontario, without implying, in any way, that such improvement is difficult of attainment.

Since co-ordination is essential in preventing both the initiation of conflicting activities and duplication of effort, it is suggested that all entomological work performed in Ontario by either the Dominion, the Province or the industry acting either separately or in co-operation with each other, be co-ordinated through a supervising committee consisting of representatives of the three agencies involved.

Several alternatives to the above proposal merit consideration. Among these the following are specifically indicated:

1. The establishment of a special committee on Forest Entomology under the Ontario Advisory Committee on Forestry as part of the Ontario Research Commission.

2. Recourse to the Forest Insect Control Board as an established co-ordinating agency whose interests extend to the problems of individual provinces as well as to those which are Dominion wide in scope.

Some suggestions regarding division of responsibility among the various agencies concerned with forest entomology in Ontario should probably be given to focus attention on the contributions which will be required in the further development of this field of activity:

(i) The Division of Entomology of the Dominion Department of Agriculture should continue to be responsible for: (a) the execution of fundamental research in the laboratory and in the field in matters relating to insect bionomics, genetics, physiology, natural and biological control, ecology, etc. (b) the conduct of the Forest Insect Survey on a co-operative basis, as hitherto, with increased contributions from the Department of Lands and Forests and from the forest industries; (c) biological control work involving insect parasites, predators, and disease-causing microorganisms, including the fundamental research connected with the evaluation of effectiveness of these agents, as well as propagation and distribution in the field; (d) extending the Forest Insect Ranger service and associated technical staff to the point where it will be possible to attach personnel to other organizations in the Province for short periods or longer, if necessary, for the evaluation of hazards, the need of salvage operations, and supervision of same in respect of forested areas requiring special treatment.

(ii) Suggested responsibilities of the Department of Lands and Forests of Ontario include: (a) continuation of the existing co-operation in field surveys and particularly contributions to the Forest Insect Survey; (b) promotion of joint action in special forest insect problems, especially those arising as a result of logging conditions (e.g. co-operative programs of surveys, both ground (aerial) and photographic, for determination of extent of infestation and damage); (c) encouragement, by regulation of cutting, or otherwise, of the salvage of timber, weakened, dying, or dead as a result of insect activity, in order to recover economic values without waste and, in some cases, to reduce the likelihood of more extensive infestations.

(iii) The responsibilities of private industry in the Province in the program of forest insect work would include: (a) continuation of active co-operation in the Forest Insect Survey by submitting samples, and by submitting reports on special conditions in forested areas held under lease by the respective industrial units. (b) carrying out, where feasible, measures such as salvage and special cutting operations where these may be deemed necessary, to conserve forest resources, or to reduce the likelihood of increased damage.

All agencies contributing to the cause of forest entomology in Ontario have a special and joint responsibility in the matter of salvage of at least a part of the tremendous volumes of dead timber resulting from insect outbreaks. Neglect of the possibilities of salvage of such timber, while active cutting programs are in progress in the same or adjacent territories, involving the exploitation of

non-susceptible timber species, can [illegible] to the wastage of much needed timber resources, and reduction of reserves for the future. In the present and expected future demand for all forest products, such wastage can hardly be attributed [illegible] of markets. Moreover, such wastage would seem to imply that the operating firms have no need of depending upon the affected volumes of timber. If this point of view were carried out to its logical conclusion, it would seem to mean that additional industrial units could be supported by the forests of Ontario to the extent that each industrial unit required all of the timber production on the land held under lease, for its continued existence. Under such conditions, recovery would be made of cull and timber; and the forests would be kept in operation in such a way that each area would be exploited sufficiently frequently to avoid the accumulation of volumes of overmature timber, and to provide some hope of regulating stand condition. Moreover, the industrial wealth of the Province would be increased and support provided for considerable additional population.